

# **Nevada Test Site**

## **2006 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site**

**February 2007**

**Prepared for:**

**U.S. Department of Energy  
National Nuclear Security Administration  
Nevada Site Office**



**Prepared by:**

**National Security Technologies, LLC  
Las Vegas, Nevada**

***National Security Technologies LLC***

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**February 2007**

**Work Performed Under  
Contract No. DE-AC52-06NV-25946**

**Prepared for:**

**U.S. Department of Energy  
National Nuclear Security Administration  
Nevada Site Office**

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**LIST OF ACRONYMS AND ABBREVIATIONS**

AMSL	above mean sea level
BN	Bechtel Nevada
°C	degrees Celsius
Ca	calcium
Cl	chloride
cm	centimeter
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
E	Easting
F	fluoride
Fe	iron
ft	feet
GW	groundwater
HCO <sub>3</sub>	bicarbonate
IL	investigation level
In.	inch
K	potassium
L	liter
LCA	lower carbonate aquifer
m	meter
MDC	minimum detectable concentration
MDL	method detection limit
mg	milligram
Mg	magnesium
mmhos	milli-mhos
Mn	manganese
N	Northing
Na	Sodium
NDEP	Nevada Division of Environmental Protection
NSTec	National Security Technologies, LLC
NTS	Nevada Test Site
pCi/L	picoCurie per liter
RCRA	Resource Conservation and Recovery Act
REECo	Reynolds Electrical & Engineering Company, Inc.
RWMS	Radioactive Waste Management Site
SC	specific conductance
SiO <sub>2</sub>	silicate
SO <sub>4</sub>	sulfate
TOC	total organic carbon
TOX	total organic halides
µg	microgram
yr	year

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## **EXECUTIVE SUMMARY**

This report is a compilation of the groundwater sampling results from the Area 5 Radioactive Waste Management Site (RWMS) for calendar year 2006. Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 were sampled in April and October 2006 for the following indicators of contamination: pH, specific conductance, total organic carbon, total organic halides, and tritium. Indicators of general water chemistry (cations and anions) were also monitored. Results from all samples collected in 2006 were within the limits established by agreement with the Nevada Division of Environmental Protection for each analyte. These data indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS.

There were no significant changes in measured groundwater parameters compared to previous years.

Other information in the report includes an updated Cumulative Chronology for the Area 5 RWMS Groundwater Monitoring Program and a brief description of the site hydrogeology.

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## **I. INTRODUCTION**

### **A. Purpose and Scope**

This report is a compilation of the groundwater sampling results from three monitoring wells located near the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada Test Site (NTS), Nye County, Nevada for calendar year 2006. The NTS is a 3561-square-kilometer (1375-square-mile) restricted-access federal installation located approximately 105 kilometers (65 miles) northwest of Las Vegas, NV (Figure 1). Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 are used to monitor the groundwater at the Area 5 RWMS (Figure 2). In addition to providing groundwater monitoring results, this report also includes information regarding site hydrogeology, well construction, sample collection, and meteorological data measured at the Area 5 RWMS.

The disposal of low-level radioactive waste and mixed low-level radioactive waste at the Area 5 RWMS is regulated by U.S. Department of Energy (DOE) Order 435.1 and the disposal of mixed low-level radioactive waste is also regulated by the state of Nevada under the Resource Conservation and Recovery Act (RCRA) regulation Title 40 Code of Federal Regulation (CFR) 265. The format of this report was requested by the Nevada Division of Environmental Protection (NDEP) in a letter dated August 12, 1997. The appearance and arrangement of this document have been modified slightly since that date to provide additional information and to facilitate the readability of the document. The objective of this report is to satisfy any Area 5 RWMS reporting agreements between DOE and NDEP.

### **B. Site Hydrogeology**

The Area 5 RWMS is located in northern Frenchman Flat in the southeast portion of the NTS. Frenchman Flat is a topographically closed basin. Erosion of surrounding mountains has resulted in accumulation of thick, unsaturated, alluvial deposits above volcanic rocks within the basin (Bright et al., 2001). Alluvial and volcanic aquifers are present beneath the Area 5 RWMS and are believed to extend throughout much of the Frenchman Flat basin (International Technology Corporation, 1998). In this south-central portion of the NTS, a moderately thick volcanic confining unit, consisting of altered volcanic rocks, separates the shallow alluvial and volcanic aquifers from the underlying regional lower carbonate aquifer (LCA) (Laczniak et al., 1996).

Sodium-bicarbonate type water comes from the three monitoring wells (UE5PW-1, UE5PW-2, and UE5PW-3). This type of water is common in the upper aquifers in Frenchman Flat. Similar groundwater chemistry and water-table elevations in UE5PW-1, UE5PW-2, and UE5PW-3 indicate that the alluvial and volcanic aquifers are locally connected near the Area 5 RWMS. UE5PW-1 and UE5PW-2 are completed in the alluvial aquifer and UE5PW-3 is completed in the volcanic aquifer.

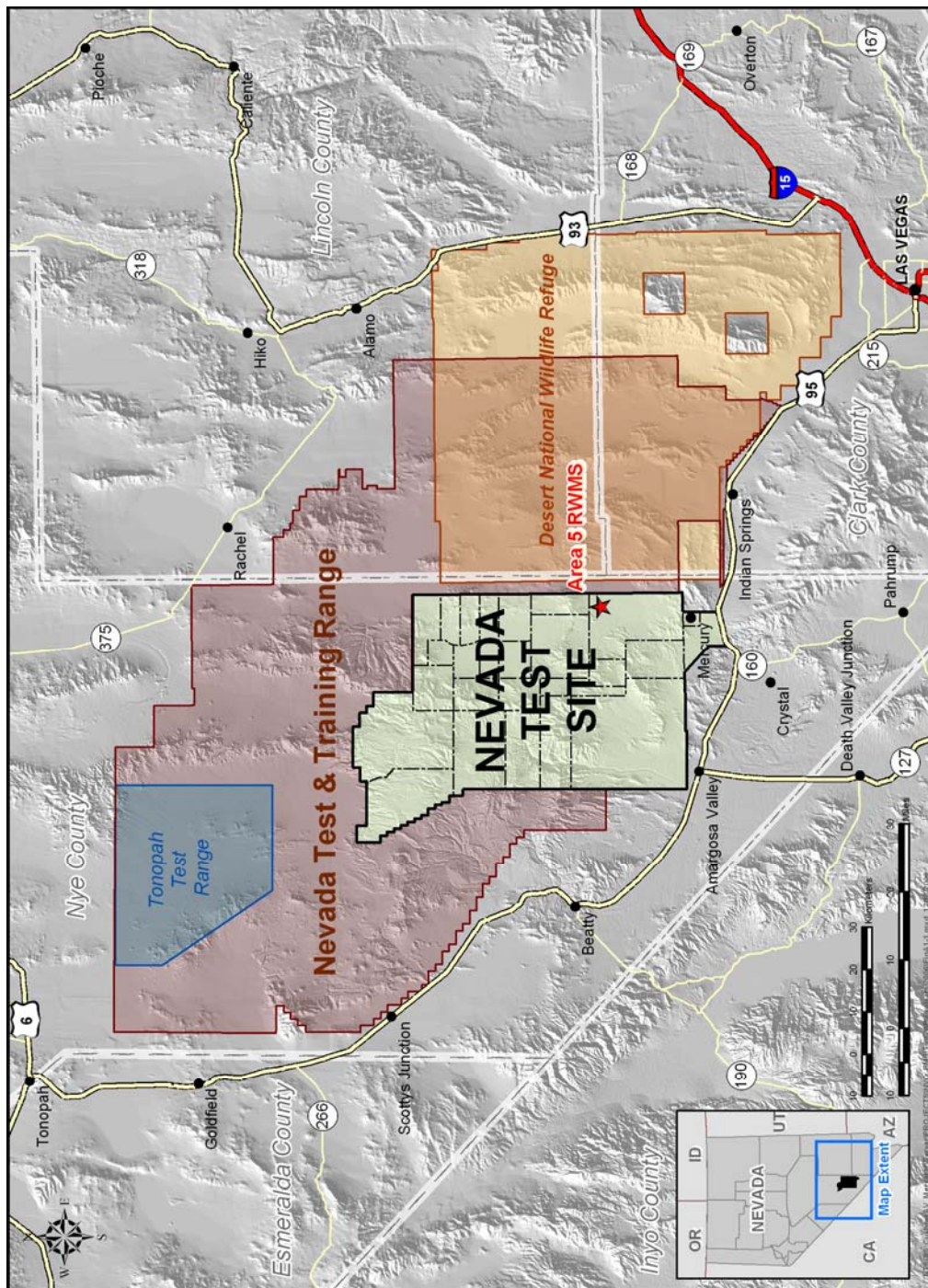


Figure 1. Location of the Area 5 RWMS and Nevada Test Site within Nevada



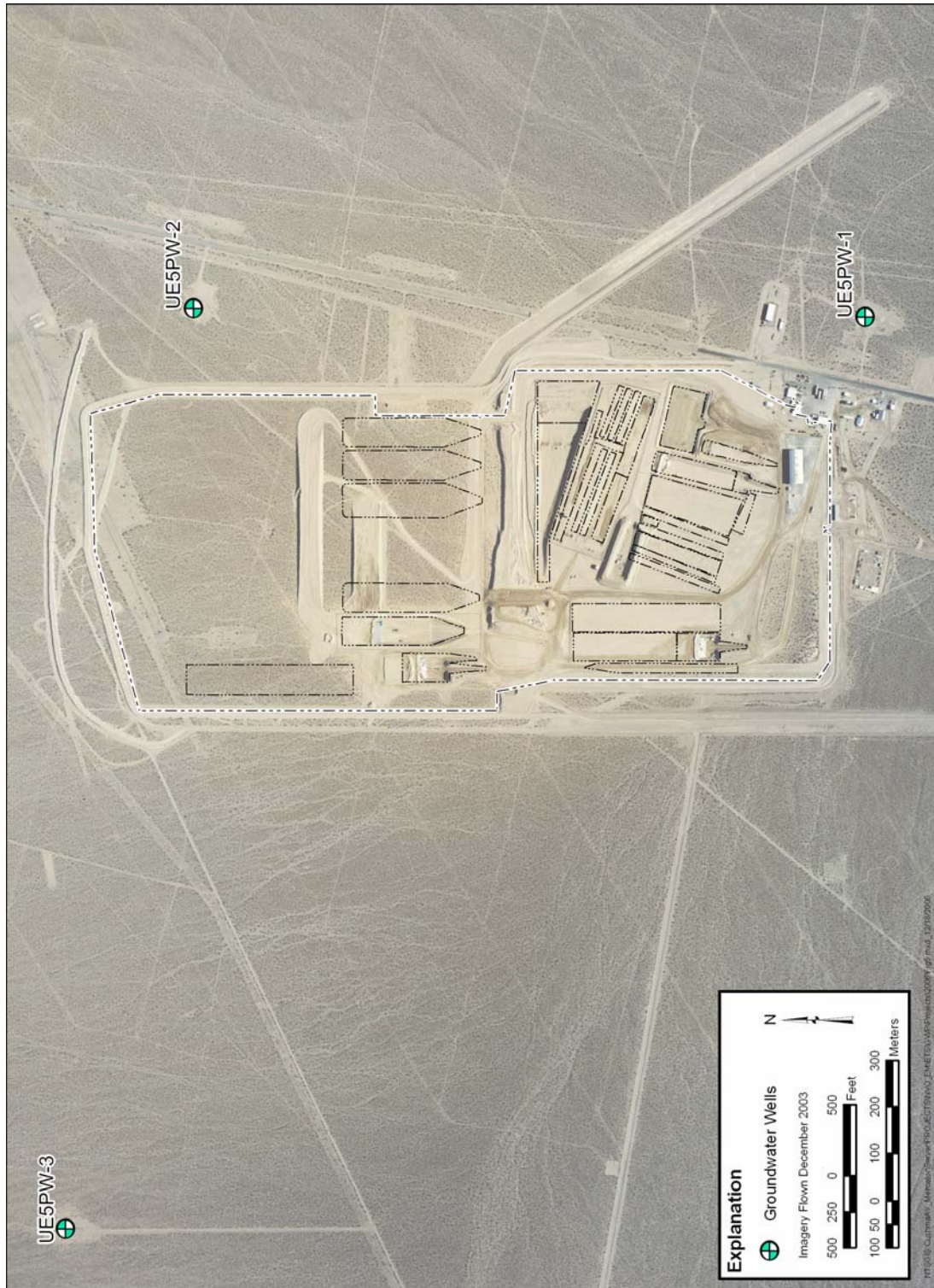


Figure 2. Location of Pilot Wells at the Area 5 RWMS

Some vertical groundwater flow is thought to occur between the uppermost aquifers and the underlying regional LCA, and is being studied by the Underground Test Area Project. Based on measured groundwater elevations above mean sea level (AMSL) (Figure 3), the hydraulic gradient in Frenchman Flat is very low. Lateral groundwater movement beneath Frenchman Flat primarily occurs within the deep carbonate aquifer and is generally from the northeast to southwest. It eventually discharges in Amargosa Valley and Ash Meadows in southwest Nevada and Death Valley in California (Figure 4) (Laczniak et al., 1996).

For more detailed descriptions of Area 5 RWMS site characteristics, refer to *Revised Area 5 Radioactive Waste Management Site Outline of a Comprehensive Groundwater Monitoring Program* (Bechtel Nevada [BN], 1998).

### C. Monitoring Well Descriptions

Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 were drilled between March and November 1992, and the groundwater has been monitored since 1993. Each well is completed with a centralized 6.35-centimeter (cm) (2.50-inch [in.]) diameter stainless steel casing with an 18.3-meter (m) (60-feet [ft]) dual-screen filter pack attached to the bottom of the casing. The borehole annulus below and around the screen is filled with 6/12 coarse mesh sand (Reynolds Electrical & Engineering Company, Inc. [REECo], 1994).

UE5PW-1 is 255.7 m (839 ft) deep from top of casing and is screened from 232.3 m (762 ft) to 250.5 m (822 ft). UE5PW-1 is completed in alluvium. During 2006, the average water table depth below the top of the well casing was 235.72 m (773.36 ft).

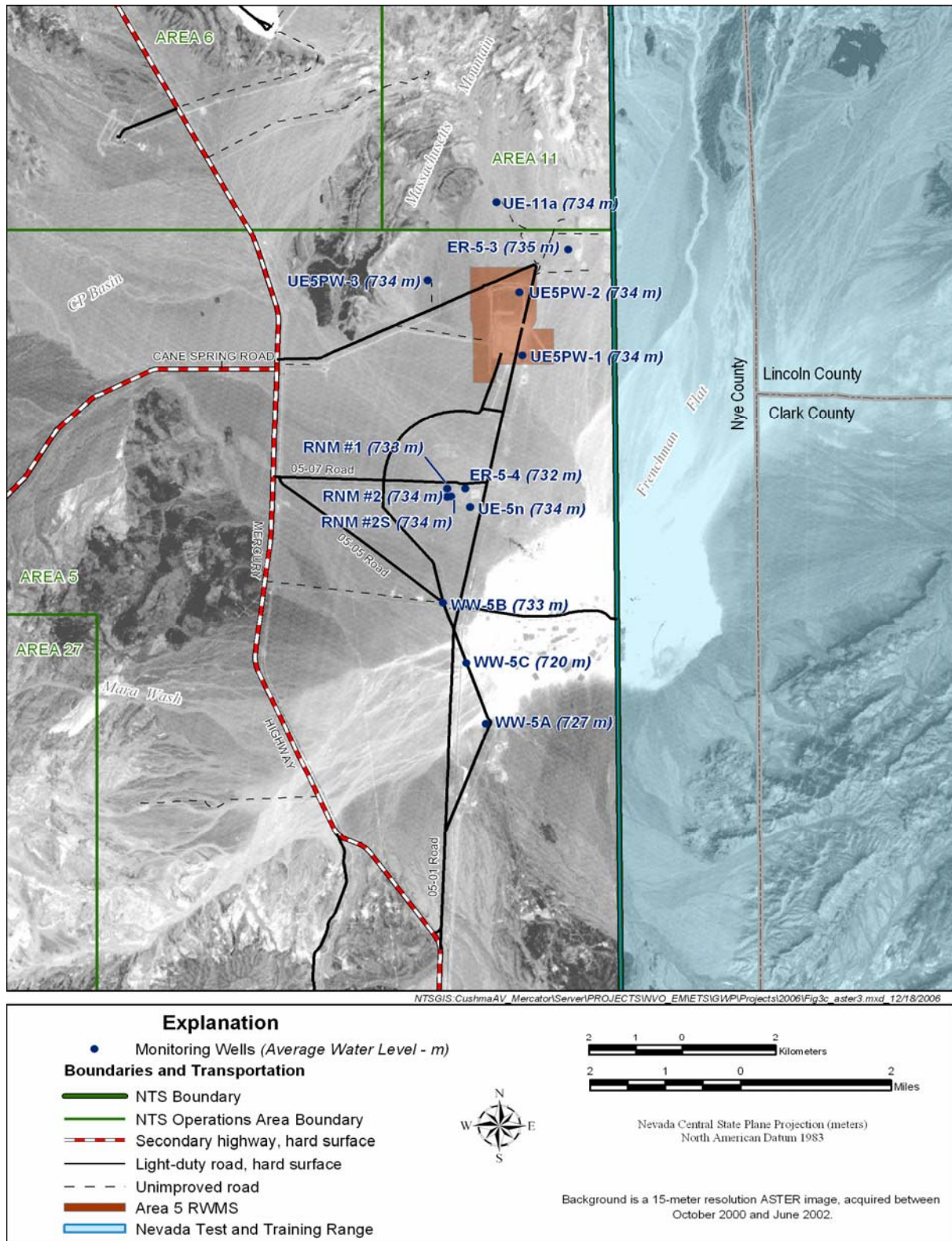
UE5PW-2 is 280.3 m (919.5 ft) deep from top of casing and is screened from 253.0 m (830 ft) to 271.3 m (890 ft). UE5PW-2 is completed in alluvium. During 2006, the average water table depth below the top of the well casing was 256.40 m (841.20 ft).

UE5PW-3 is 291.1 m (955 ft) deep from top of casing and is screened from 267.6 m (878 ft) to 282.9 m (928 ft). UE5PW-3 is completed in volcanic rock. The alluvium-volcanic rock contact is 188 m (617 ft) deep at UE5PW-3 (REECo, 1994). During 2006, the average water table depth below the top of the well casing was 271.44 m (890.79 ft).

### D. Site Meteorology

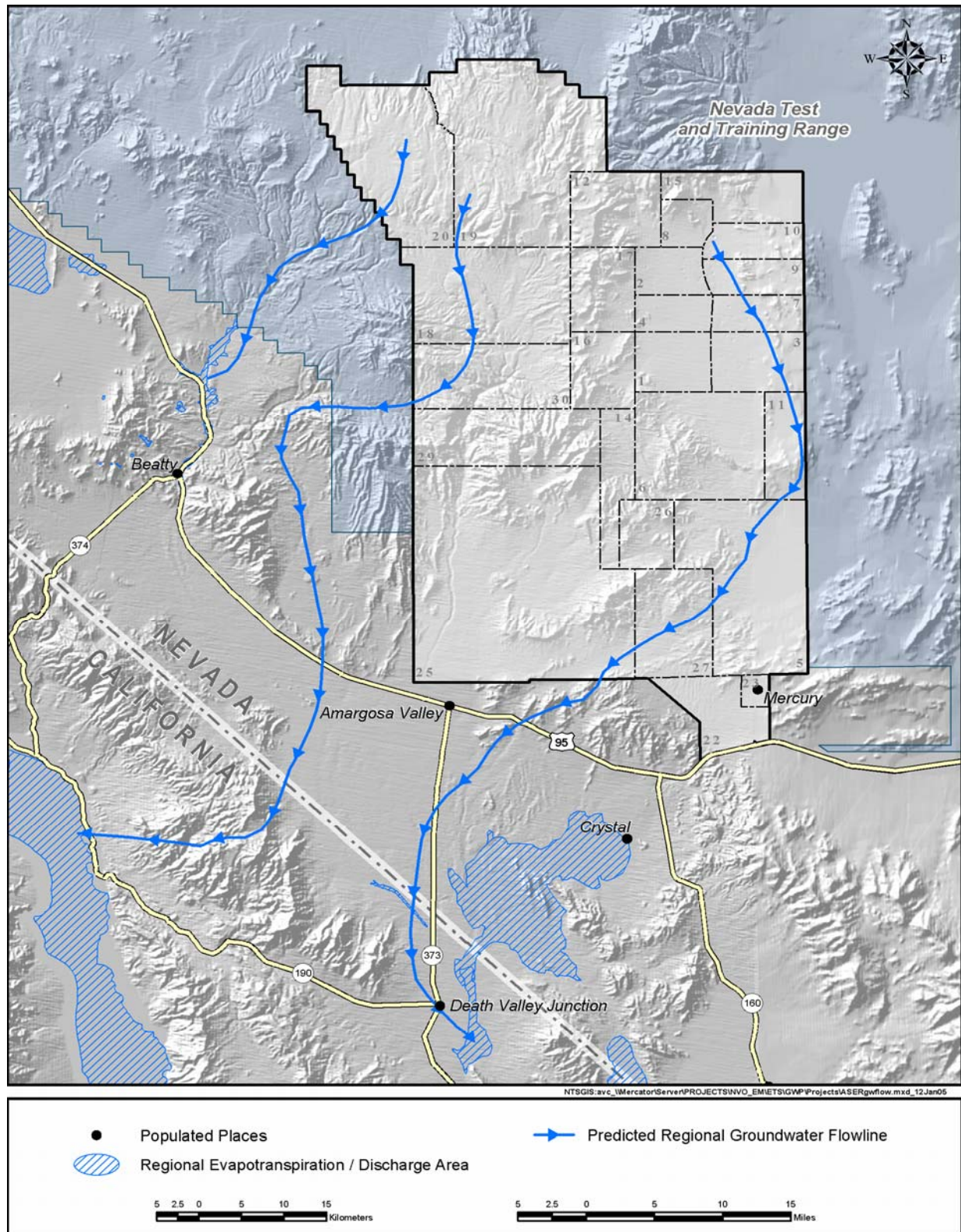
Meteorological data are measured at the Area 5 RWMS. These data includes temperature, relative humidity, barometric pressure, wind speed and direction, and precipitation. The average annual precipitation measured at the Area 5 RWMS from 1994 through 2006 was 12.9 cm per year (cm/yr) (5.08 in/yr). There was 8.1 cm (3.19 in.) of precipitation at the Area 5 RWMS in 2006. Monthly precipitation at the Area 5 RWMS is provided in Figure 5.



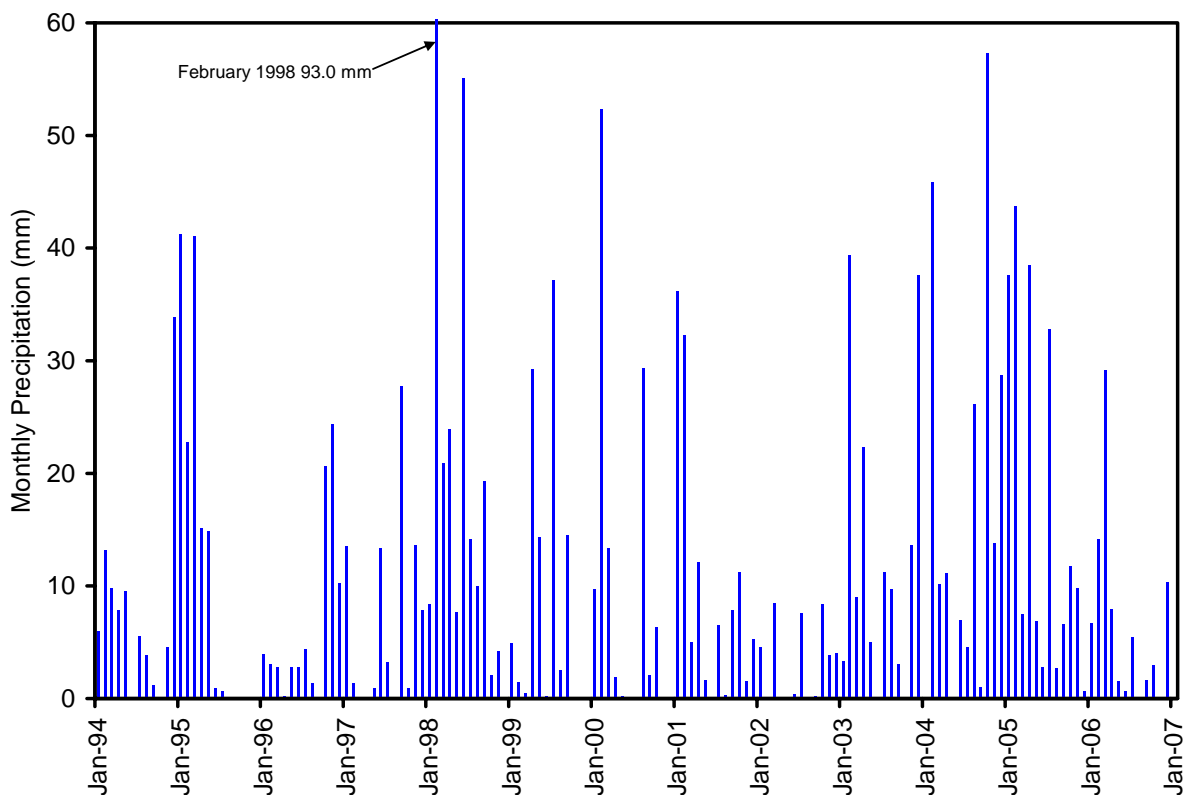


**Figure 3. Location and Average Water Level Elevations of Area 5 RWMS Groundwater Monitoring Wells and other Wells in the Vicinity (USGS, 2006)**





**Figure 4. Nevada Test Site Predicted Regional Groundwater Flow Paths (BN, 2001)**



**Figure 5. Area 5 RWMS Monthly Precipitation**

## II. MONITORING METHODS AND RESULTS

The Area 5 RWMS pilot wells have been monitored since 1993 (Appendix A-Cumulative Chronology for Area 5 RWMS Groundwater Monitoring Program). The groundwater monitoring program has transitioned from monitoring all parameters required by Title 40 CFR 265 to a program that monitors parameters applicable to the Area 5 RWMS site. The current monitoring program is modeled after the Title 40 CFR 265 detection-monitoring program. The analytes listed below are sampled semiannually and are divided into groups representing indicators of contamination and general water chemistry parameters:

Indicators of contamination:

- pH
- Specific conductance (SC)
- Total organic carbon (TOC)
- Total organic halides (TOX)
- Tritium

General water chemistry parameters:

- Total calcium (Ca), iron (Fe), magnesium (Mg), manganese (Mn), potassium (K), sodium (Na), silicate ( $\text{SiO}_2$ )
- Total sulfate ( $\text{SO}_4$ ), chloride (Cl), fluoride (F)
- Alkalinity (as bicarbonate [ $\text{HCO}_3$ ])

Investigation levels (ILs) for each analyte identified as an indicator of contamination were established by DOE and NDEP in 1998 (Table 1). Further groundwater analyses are required if an analyte's IL is exceeded. The intent of ILs is to replace the need for rigorous statistical analyses to identify contamination. Statistical analyses are not presented in this report, as agreed upon by NDEP in a letter dated April 17, 2000 (Liebendorfer, 2000). The ILs for pH and SC are based on the distributions of data collected from 1993 through 1996. Historic analyses for TOC, TOX, and tritium have typically reported concentration levels less than the method detection limit (MDL) or the minimum detectable concentration (MDC), so the ILs for TOC and TOX are set slightly above their MDLs or MDCs. The tritium IL is set at 2,000 picoCuries per liter (pCi/L), which is 10 percent of the National Primary Drinking Water Standard of 20,000 pCi/L.

**Table 1. Investigation Levels for Indicator Parameters**

Parameter	Investigation Level (IL)
pH	< 7.6 or > 9.2
SC	0.440 mmhos/cm <sup>a</sup>
TOC	1 mg/L <sup>b</sup>
TOX	50 µg/L <sup>c</sup>
Tritium	2,000 pCi/L

(a) mmhos/cm = millimhos per centimeter

(b) mg/L = milligrams per liter

(c) µg/L = micrograms per liter

Wells UE5PW-1, UE5PW-2, and UE5PW-3 were sampled on April 26, 2006 and October 10, 2006 using the current groundwater sampling procedure (National Security Technologies, LLC [NSTec], 2006). Tritium samples were enriched prior to shipment to a contract laboratory. Analyses for tritium were conducted by Sanford, Cohen & Associates Southeastern Environmental Laboratory, and nonradiological analyses were conducted by Lionville Laboratory Incorporated.

For TOC and TOX analysis, three replicate water samples were collected consecutively from each well for each analyte. This provides sufficient sample backups in case any sample result is above the analyte's IL. Well resampling is required if all three replicate water samples are above the analyte's IL. False detections of these analytes above their ILs and subsequent resampling of the wells have occurred in the past.

**A. pH**

The measured pH at each well remained within the ILs of 7.6 and 9.2 during 2006 (Table 2). The 2006 pH values ranged from 8.03 to 8.34 and represent the stable pH reading obtained from each well just prior to sampling for other analytes. Measured pH has remained relatively stable throughout the entire monitoring period (Figure 6). No groundwater contamination is indicated by the pH monitoring results.

**Table 2. Area 5 RWMS pH Values**

UE5PW-1		UE5PW-2		UE5PW-3	
Date	pH	Date	pH	Date	pH
03/31/1993	8.17	03/24/1993	7.99	04/14/1993	8.24
06/06/1993	8.30	06/22/1993	8.24	06/02/1993	8.67
09/01/1993	8.25	No sample		10/12/1993	8.69
12/07/1993	7.91	11/15/1993	8.39	12/20/1993	8.60
06/15/1994	8.45	06/07/1994	8.81	05/24/1994	8.87
08/01/1994	8.28	No sample		08/08/1994	8.77
No sample		11/29/1994	8.79	No sample	
No sample		No sample		01/18/1995	8.58
04/04/1995	8.25	04/04/1995	8.58	04/05/1995	8.28
11/09/1995	8.35	11/09/1995	8.08	11/09/1995	8.43
01/18/1996	8.41	01/25/1996	8.63	01/18/1996	8.55
04/16/1996	8.22	04/23/1996	8.21	04/23/1996	8.23
No sample		04/30/1996	8.15	04/30/1996	8.15
10/02/1996	8.18	10/02/1996	8.28	10/02/1996	8.18
11/20/1996	8.25	11/20/1996	8.17	11/20/1996	8.13
04/16/1997	8.32	04/16/1997	8.40	04/16/1997	8.25
11/05/1997	8.30	11/05/1997	8.16	11/05/1997	8.22
05/13/1998	8.31	05/13/1998	8.37	05/13/1998	8.34
07/29/1998	8.63	No sample		No sample	
10/28/1998	8.34	10/28/1998	8.32	10/28/1998	8.14
05/19/1999	8.50	05/19/1999	8.49	05/19/1999	8.47
10/27/1999	8.49	10/27/1999	8.52	10/27/1999	8.34
04/26/2000	8.50	04/26/2000	8.39	04/26/2000	8.24
08/09/2000	8.26	08/09/2000	8.14	08/09/2000	8.23
05/29/2001	8.46	05/29/2001	8.25	05/29/2001	8.27
10/03/2001	8.39	10/03/2001	8.22	10/03/2001	8.13
05/15/2002	8.46	05/15/2002	8.30	05/15/2002	8.32
10/22/2002	8.43	10/22/2002	8.23	10/22/2002	8.24
04/15/2003	8.54	04/15/2003	8.38	04/15/2003	8.42
10/22/2003	8.37	10/22/2003	8.24	10/21/2003	8.16
05/04/2004	8.50	05/04/2004	8.25	05/04/2004	8.26
10/19/2004	8.30	10/19/2004	8.32	10/20/2004	8.24
04/19/2005	8.48	04/19/2005	8.30	04/19/2005	8.33
10/11/2005	8.47	10/11/2005	8.27	10/11/2005	8.31
04/26/2006	8.34	04/26/2006	8.12	04/26/2006	8.17
10/10/2006	8.11	10/10/2006	8.03	10/10/2006	8.07

Data source: Data taken from original sample packages or field notebooks and represent the stable pH value measured just prior to sampling.

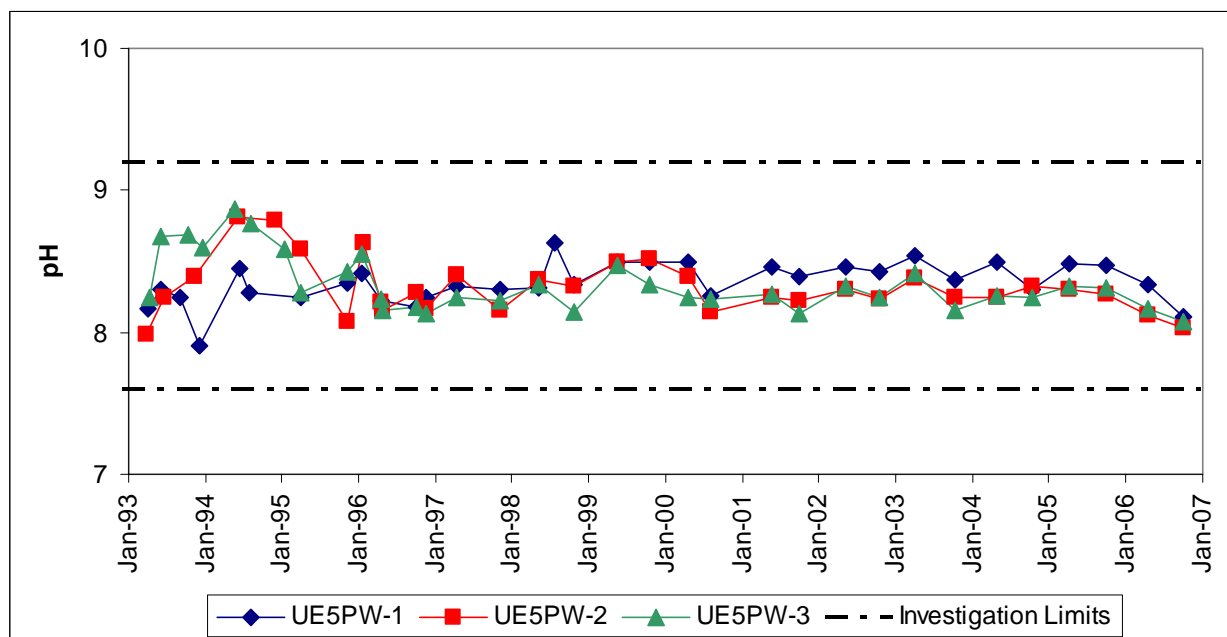


Figure 6. Area 5 RWMS Time Series Plot of pH

## B. Specific Conductance

The 2006 measured SC of water samples from each well remained below the IL of 0.440 mmhos/cm and ranged from 0.341 to 0.384 mmhos/cm (Table 3). SC values from each well have remained relatively stable throughout the entire monitoring period (Figure 7). No groundwater contamination is indicated by the SC monitoring results.

Table 3 Area 5 RWMS SC Values in mmhos/cm

UE5PW-1		UE5PW-2		UE5PW-3	
Date	SC	Date	SC	Date	SC
03/31/1993	0.401	03/24/1993	0.371	04/14/1993	0.383
06/06/1993	0.391	06/22/1993	0.411	06/02/1993	0.382
09/01/1993	0.391	No Sample		10/12/1993	0.376
12/07/1993	0.383	11/15/1993	0.384	12/20/1993	0.356
06/15/1994	0.383	06/07/1994	0.363	05/24/1994	0.363
08/01/1994	0.380	No Sample		08/08/1994	0.367
No Sample		11/29/1994	0.325	No Sample	
No Sample		No Sample		01/18/1995	0.338
04/04/1995	0.320	04/04/1995	0.336	04/05/1995	0.347
11/09/1995	0.366	11/09/1995	0.348	11/09/1995	0.352
01/18/1996	0.360	01/25/1996	0.343	01/18/1996	0.355
04/16/1996	0.363	04/23/1996	0.355	04/23/1996	0.363

Table 3. Area 5 RWMS SC Values in mmhos/cm (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	SC	Date	SC	Date	SC
No Sample		04/30/1996	0.356	04/30/1996	0.379
10/02/1996	0.383	10/02/1996	0.363	10/02/1996	0.376
11/20/1996	0.374	11/20/1996	0.365	11/20/1996	0.378
04/16/1997	0.385	04/16/1997	0.363	04/16/1997	0.376
11/05/1997	0.376	11/05/1997	0.358	11/05/1997	0.361
05/13/1998	0.377	05/13/1998	0.356	05/13/1998	0.370
07/29/1998	0.373	No Sample		No Sample	
10/28/1998	0.380	10/28/1998	0.358	10/28/1998	0.370
05/19/1999	0.379	05/19/1999	0.351	05/19/1999	0.369
10/27/1999	0.370	10/27/1999	0.355	10/27/1999	0.370
04/26/2000	0.378	04/26/2000	0.355	04/26/2000	0.369
08/09/2000	0.378	08/09/2000	0.357	08/09/2000	0.370
05/29/2001	0.377	05/29/2001	0.358	05/29/2001	0.371
10/03/2001	0.376	10/03/2001	0.358	10/03/2001	0.371
05/15/2002	0.386	05/15/2002	0.374	05/15/2002	0.384
10/22/2002	0.374	10/22/2002	0.368	10/22/2002	0.368
04/15/2003	0.372	04/15/2003	0.355	04/15/2003	0.369
10/22/2003	0.376	10/22/2003	0.357	10/21/2003	0.373
05/04/2004	0.378	05/04/2004	0.361	05/04/2004	0.353
10/19/2004	0.372	10/19/2004	0.352	10/20/2004	0.365
04/19/2005	0.377	04/19/2005	0.359	04/19/2005	0.369
10/11/2005	0.368	10/11/2005	0.352	10/11/2005	0.364
04/26/2006	0.361	04/26/2006	0.341	04/26/2006	0.357
10/10/2006	0.384	10/10/2006	0.363	10/10/2006	0.376

Data source: Data taken from original sample packages or field notebooks and represent the stable SC value measured just prior to sampling.

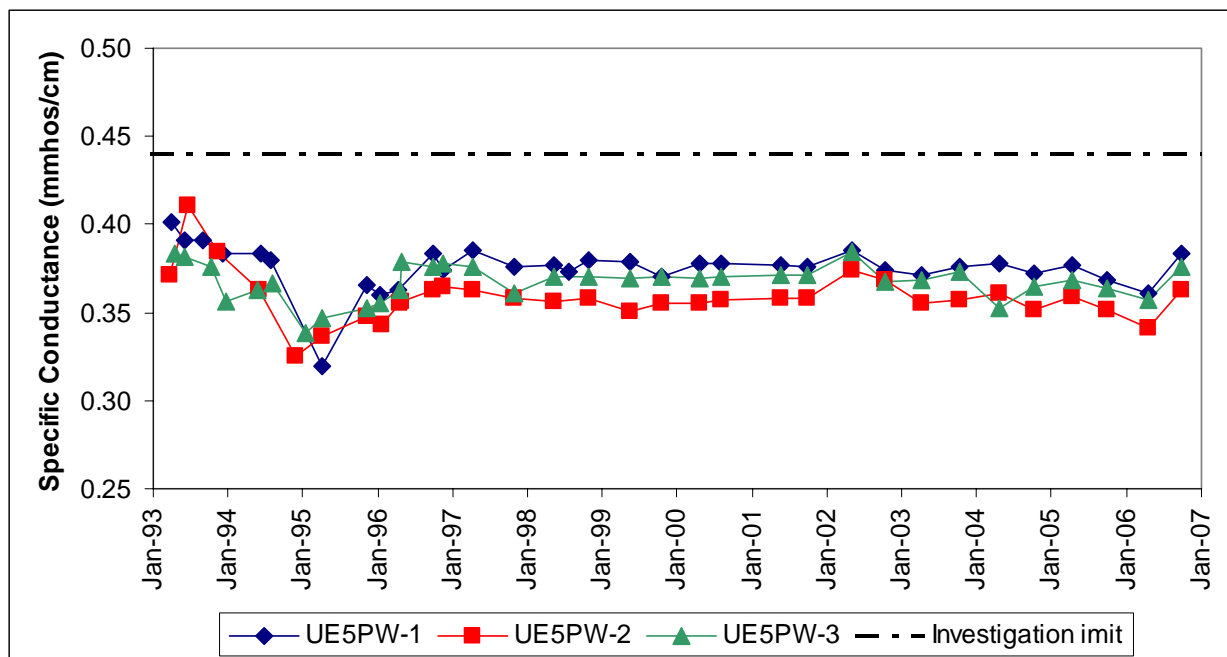


Figure 7. Area 5 RWMS Time Series Plot of SC

### C. Total Organic Carbon

In 2006, three samples were collected from each well on both sample dates and the averages of the three sample measurements are reported (Table 4). When sample TOC values fell below the sample's MDL of 0.5 mg/L, then 0.5 mg/L was the value used in calculating the reported average. Values shown as <0.5 mg/L indicate that all three sample results were less than the MDL. Five of the six TOC average values for 2006 are below the IL of 1 mg/L. The average TOC value for the October 2006 samples from UE5PW-2 is 1.12 mg/L. The three measured values for this average are 2.3 mg/L, 0.56 mg/L, and <0.5 mg/L. No resampling or reanalysis was done because only one of the three measurements for this well was above the IL.

TOC values have remained relatively low and stable throughout the monitoring period (Figure 8). Most variation in TOC values is the result of variation in the MDL. No groundwater contamination is indicated by the TOC monitoring results.



Table 4. Area 5 RWMS TOC Values in mg/L

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
March 1993	<1.0	<1.0	No sample
April 1993	No sample	No sample	<1.0
June 1993	<1.0	<1.0	<1.0
September 1993	<1.0	No sample	No sample
October 1993	No sample	No sample	<1.0
November 1993	No sample	<1.0	No sample
December 1993	<1.0	No sample	<1.0
June 1994	No sample	<1.0	No sample
August 1994	1.7 <sup>a</sup>	No sample	<1.0
November 1994	No sample	<1.0	No sample
January 1995	0.2	0.5	0.22
April 1995	<1.0	<1.0	<1.0
November 1995	<1.0	<1.0	<1.0
April 1996	<0.3	<0.3	<0.3
October 1996	<0.3	<0.3	<0.3
November 1996	<0.3	<0.3	<0.3
April 1997	<0.3	<0.3	<0.3
November 1997	<0.3	<0.3	<0.3
May 1998	<1.0	<1.0	<1.0
October 1998	<1.0	<1.0	<1.0
May 1999 <sup>b</sup>	<1.0	<1.0	<1.0
October 1999 <sup>b</sup>	<1.0	1.6 <sup>a</sup>	<1.0
December 1999	No sample	<0.5	No sample
April 2000	0.98 <sup>a</sup>	0.60 <sup>a</sup>	1.31 <sup>a</sup>
August 2000	<0.5 <sup>c</sup>	<0.5 <sup>c</sup>	<0.5 <sup>c</sup>
May 2001	0.51 <sup>c</sup>	<0.5 <sup>c</sup>	0.53 <sup>c</sup>
October 2001	<0.5	<0.5	<0.5
May 2002	<0.5	<0.5	<0.5
October 2002	<0.5	0.55	0.58
April 2003	0.51	0.58	0.52
October 2003	0.64	0.68	0.62
May 2004	0.55	<0.5	0.58
October 2004	0.58	0.90	0.83
April 2005	0.65	0.62	0.50
October 2005	0.60	0.53	<0.5
April 2006	<0.5	0.97	0.51
October 2006	0.80	1.12	0.52

(a) Determined to be a false positive through resampling.

(b) Data from BN, 2001.

(c) Multiple laboratories used, this value represents the Lionville Laboratory Incorporated result only.

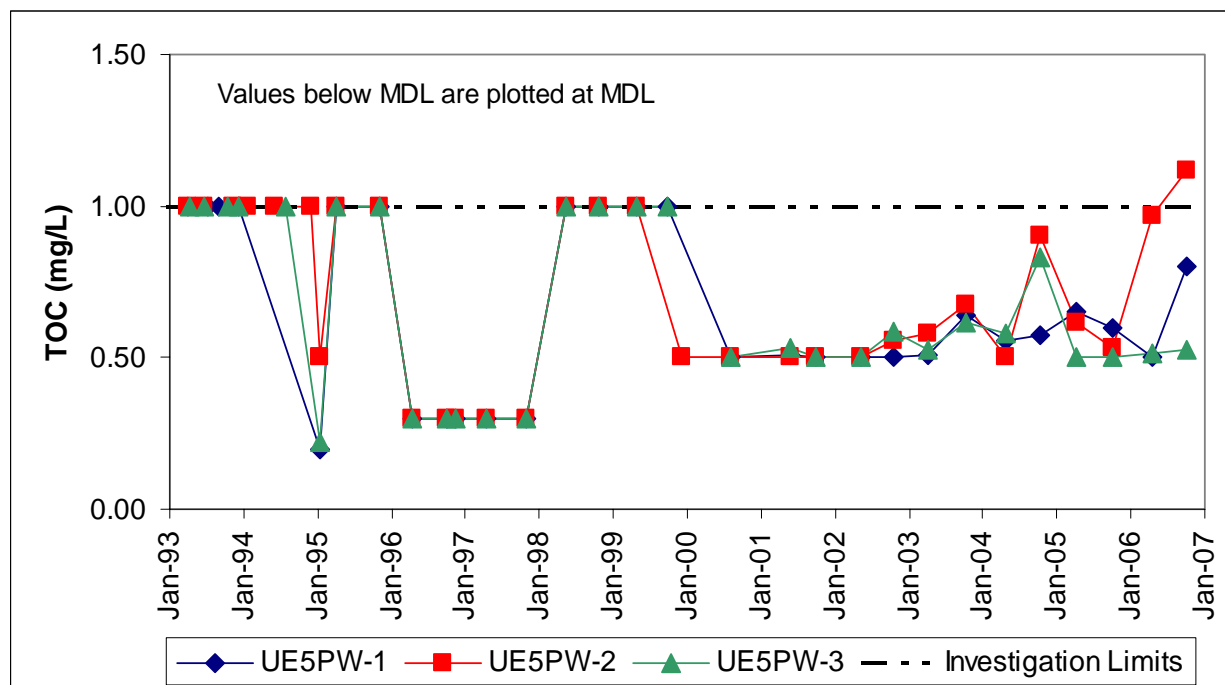


Figure 8. Area 5 RWMS Time Series Plot of Total Organic Carbon

#### D. Total Organic Halides

All 2006 TOX results are below the IL of 50  $\mu\text{g/L}$  (Table 5). In 2006, three samples were collected from each well on each sample date and the averages of the three sample measures are reported. When sample TOX values fell below the sample's MDL of 5.0  $\mu\text{g/L}$ , then 5.0  $\mu\text{g/L}$  was the value used in calculating the reported average. Values shown as <5.0  $\mu\text{g/L}$  indicate that all three samples were less than the MDL.

TOX values have remained relatively stable and below the IL throughout the monitoring period (Figure 9). No groundwater contamination is indicated by the TOX results.

Table 5. Area 5 RWMS TOX Values in  $\mu\text{g/L}$

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
March 1993	20	23	No sample
April 1993	No sample	No sample	<10
June 1993	<10	<10	20 <sup>a</sup>
September 1993	20 <sup>a</sup>	<10	No sample
October 1993	No sample	No sample	<10
November 1993	No sample	<10	No sample

Table 5. Area 5 RWMS TOX Values in µg/L (continued)

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
December 1993	<10	No sample	<10
January 1994	No sample	<10	No sample
June 1994	<10	<10	No sample
August 1994	12 <sup>a</sup>	No sample	<10
November 1994	No sample	14 <sup>a</sup>	No sample
January 1995	<10	<10	<10
April 1995	<10	<10	<10
November 1995	<40	<40	<40
April 1996	<40	<40	<40
October 1996	<20	<20	<20
November 1996	<20	<20	<20
April 1997	<20	<20	<20
November 1997	<20	<20	<20
May 1998	391 <sup>c</sup>	842 <sup>c</sup>	1000 <sup>c</sup>
July 1998	<5	No sample	No sample
October 1998	<5	<5	<5
May 1999 <sup>b</sup>	<5	<5	<5
October 1999 <sup>b</sup>	<5	<5	9 <sup>a</sup>
April 2000	71.7 <sup>c</sup>	59.3 <sup>c</sup>	56.5 <sup>c</sup>
August 2000	91.8 <sup>c,d</sup>	73.0 <sup>c,d</sup>	82.8 <sup>c,d</sup>
May 2001	<12.6 <sup>d</sup>	<12 <sup>d</sup>	<12 <sup>d</sup>
October 2001	<6.1	<5.8	<5.2
May 2002	<5.2	5.43	<5.2
October 2002	<5.2	<5.2	<5.2
April 2003	<5.2	<5.2	<5.2
October 2003	<5.2	5.5	<5.2
May 2004	<5.2	<5.2	<5.2
October 2004	<5.2	<5.2	<5.2
April 2005	<5.0	<5.0	<5.0
October 2005	5.2	6.5	<5.0
April 2006	7.3	5.8	7.3
October 2006	5.1	<5.0	7.2

(a) Duplicate sample results were less than MDL.

(b) Data from BN, 2001.

(c) Determined to be false positive through resampling.

(d) Multiple laboratories used, this value represents the Lionville Laboratory Incorporated result only.

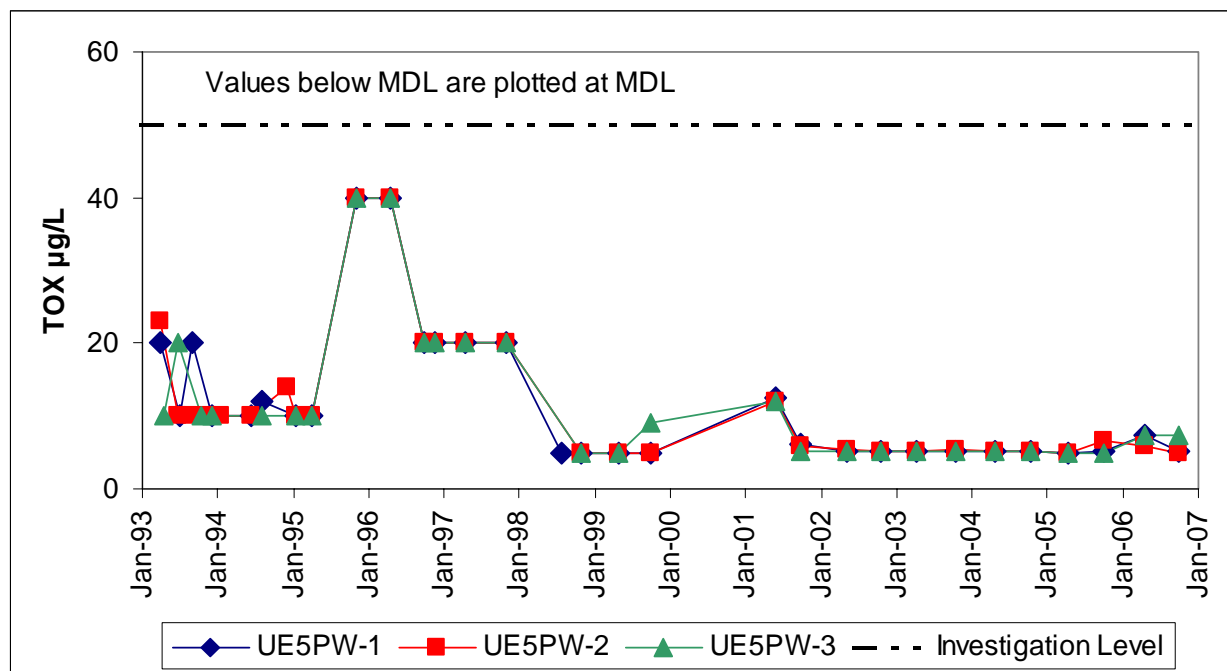


Figure 9. Area 5 RWMS Time Series Plot of TOX

### E. Tritium

All tritium results from 2006 water samples were below the IL of 2,000 pCi/L and below the laboratory MDC of approximately 20 pCi/L (Table 6). When duplicate samples were analyzed, Table 6 reports an average value.

Tritium values have remained relatively stable and below the IL and MDC throughout the monitoring period (Figure 10). No groundwater contamination is indicated by the tritium results.

Table 6. Area 5 RWMS Tritium Values in pCi/L

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
April 1993	No sample collected	No sample collected	1.96
March 1993	0.442	-4.28	No sample collected
June 1993	No sample collected	No sample collected	-2.74
November 1993	No sample collected	32.2 <sup>a</sup>	No sample collected
December 1993	-1.58	No sample collected	-0.459
January 1994	No sample collected	3.69	No sample collected
May 1994	No sample collected	No sample collected	1.13
June 1994	-2.04	1.29	No sample collected
August 1994	1.86	No sample collected	1.04
August 2000 <sup>b</sup>	-2.52	6.97	4.34
May 2001	-1.91	-11.5	-12.4
October 2001	-2.93	-2.82	2.46
May 2002	-2.82	0.151	-3.26
October 2002	-4.17	0.113	-1.17
April 2003	-1.13	-5.22	1.62
October 2003	0.950	11.4	0.405
May 2004	-2.69	-6.17	-6.04
October 2004	-1.50	-10.0	-6.38
April 2005	3.67	3.76	3.56
October 2005	8.82	5.24	-4.76
April 2006	0.480	-2.70	-6.71
October 2006	7.40	9.33	13.77

(a) Standard analysis performed, not enriched.

(b) Data from BN, 2001.

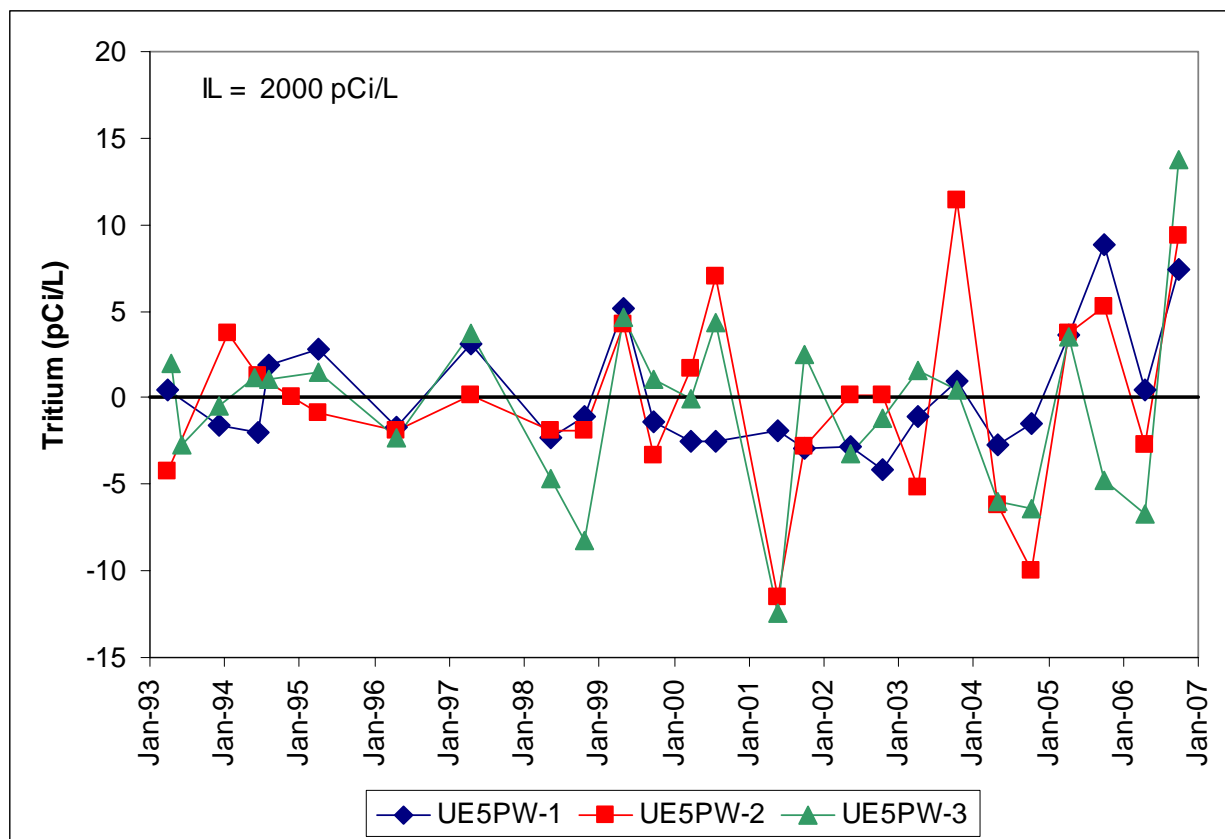


Figure 10. Area 5 RWMS Time Series Plot of Tritium

## F. General Water Chemistry Parameters

General water chemistry analyses during 2006 for cations (Ca, Mg, Na, K, Fe), anions (Cl, F, SO<sub>4</sub>, HCO<sub>3</sub>), and SiO<sub>2</sub> indicate similar groundwater in all three wells and no changes in groundwater chemistry (Table 7, Table 8, Table 9).

Groundwater temperatures measured in April 2006 ranged from 20.3 to 21.5 degrees Celsius (°C) and in October 2006 ranged from 19.6 to 21.1°C. Temperature measurements are collected at the ground surface and are influenced by the ambient air temperature.

A piper diagram for 2005 and 2006 water chemistry data indicates that the groundwater is a sodium-bicarbonate type (Figure 11). Stiff plots for these years also indicate similar groundwater chemistry for all three wells and no changes in the groundwater chemistry (Figures 12 and 13).

Table 7. UE5PW-1 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO <sub>2</sub>	SO <sub>4</sub>	HCO <sub>3</sub>	Cl	F
03/31/1993	No analysis	No analysis	No analysis	48.0	<0.006	0.013	No analysis	32	167	9.2	1.2
06/06/1993	No analysis	No analysis	No analysis	58.0	<0.001	0.059	No analysis	37	161	9.7	1.4
09/01/1993	No analysis	No analysis	No analysis	56.0	0.0066	0.027	No analysis	No analysis	158	8.4	5.7
12/07/1993	No analysis	No analysis	No analysis	57.0	<0.0012	0.012	No analysis	36	150	9.9	1.5
06/15/1994	No analysis	No analysis	No analysis	61.0	<0.004	0.01	No analysis	No analysis	No analysis	10.0	No analysis
08/01/1994	No analysis	No analysis	No analysis	53.0	<0.0012	0.021	No analysis	36	No analysis	No analysis	No analysis
04/04/1995	No analysis	No analysis	No analysis	58.0	<0.01	<0.05	No analysis	34	No analysis	9.9	No analysis
04/16/1996	No analysis	No analysis	No analysis	61.0	<0.001	0.02	No analysis	34	No analysis	9.9	No analysis
04/16/1997	15.1	5.3	5.9	54.5	<0.001	0.012	No analysis	32.2	156	9.3	1.3
11/05/1997	15.5	5.6	6.4	57.8	No analysis	0.012	No analysis	35.2	151	10.2	1.2
05/13/1998	14.0	5.4	5.2	55.8	0.0015	0.034	54.2	34.6	151	9.6	1.1
10/28/1998	14.9	5.6	6.9	57.6	0.0015	0.024	60.5	34.0	160	No analysis	1.1
05/19/1999	12.5	5.3	6.9	61.0	<0.0025	<0.05	68.5	34.0	146	10.0	1.0
10/27/1999	14.5	6.0	6.6	63.5	<0.005	<0.1	62.0	35.0	159	8.7	1.1
04/26/2000	12.8	4.8	6.7	53.7	0.001	0.032	58.3	35.6	165	10.0	1.0
08/09/2000	15.0	4.9	6.6	52.0	0.00045	< 0.0164	59.9	37.1	146	10.3	1.1
05/29/2001	14.8	4.9	6.0	58.6	< 0.0018	0.0136	62.5	No analysis	144	13.2	<1.0
10/03/2001	13.8	4.9	6.7	51.0	0.00017	< 0.0156	58.6	35.8	145	10.1	<1.0
05/15/2002	14.0	4.9	6.9	53.8	0.00016	< 0.0145	59.9	36.1	156	10.8	1.0
10/22/2002	14.7	5.2	6.4	50.0	< 0.0002	< 0.0181	61.0	35.5	146	10.3	1.0
04/15/2003	13.7	5.0	6.2	58.0	< 0.0005	0.011	59.2	32.9	150	12.3	1.0
10/22/2003	14.0	5.0	6.0	58.0	< 0.0016	0.0152	61.0	36.5	No analysis	9.4	1.0
05/04/2004	12.8	4.6	6.5	55.3	0.0021	0.029	52.0	34.5	154	9.8	1.1
10/19/2004	13.1	5.2	6.0	56.2	< 0.0003	< 0.0279	59.9	37.3	168	10.1	1.0
04/19/2005	13.8	4.8	6.6	55.1	< 0.0006	0.007	58.6	39.6	149	10.5	1.0
10/11/2005	13.4	5.0	6.1	50.5	<0.0002	<0.0260	61.2	35.7	156	9.7	1.0
04/26/2006	14.6	5.3	6.3	60.4	0.0032	0.0054	63.3	35.4	149	10.7	1.2
10/10/2006	14.0	5.2	5.9	58.8	0.0007	0.0048	61.4	33.8	148	9.9	0.9

Data source: Data from 1993 through 2000 from BN, 2001.

Table 8 UE5PW-2 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO <sub>2</sub>	SO <sub>4</sub>	HCO <sub>3</sub>	Cl	F
03/24/1993	No analysis	No analysis	No analysis	46	0.11	0.062	No analysis	28	159	8.4	1.0
06/22/1993	No analysis	No analysis	No analysis	54	0.032	0.25	No analysis	30	183	9.7	1.1
11/15/1993	No analysis	No analysis	No analysis	51	<0.004	0.180	No analysis	31	171	9.4	1.3
01/19/1994	No analysis	No analysis	No analysis	45	<0.0012	0.074	No analysis	29	159	No analysis	1.2
06/07/1994	No analysis	No analysis	No analysis	55	<0.004	0.14	No analysis	No analysis	No analysis	No analysis	No analysis
11/29/1994	No analysis	No analysis	No analysis	No analysis	No analysis	No analysis	No analysis	28	No analysis	8.0	No analysis
04/04/1995	No analysis	No analysis	No analysis	50	<0.01	<0.05	No analysis	28	No analysis	8.5	No analysis
04/30/1996	No analysis	No analysis	No analysis	51	<0.001	0.013	No analysis	29	No analysis	8.3	No analysis
04/16/1997	15.9	6.0	5.0	47.6	<0.001	0.012	No analysis	26.4	149	7.9	1.2
11/05/1997	17.4	6.8	4.9	50.6	No analysis	0.018	No analysis	28.9	140	8.6	0.9
05/13/1998	14.8	5.7	3.8	45.2	<0.0011	0.066	50.8	28.4	151	8.2	1.0
10/28/1998	15.8	6.2	5.6	47.4	0.0009	0.015	55.9	28.4	157	8.3	1.0
05/19/1999	15.0	6.3	6.2	52.0	<0.0025	<0.05	62.0	27.5	134	8.7	0.9
10/27/1999	16.0	6.7	5.7	52.0	<0.005	<0.1	55.6	28.0	159	7.4	1.0
04/26/2000	15.2	6.5	5.6	45.6	0.0007	0.029	55.8	29.1	180	8.6	0.8
08/09/2000	17.0	6.6	5.3	44.4	< 0.0002	< 0.0164	59.3	28.7	166	9.3	0.9
05/29/2001	16.7	6.6	4.8	48.2	< 0.0018	< 0.0107	60.3	No analysis	151	12.4	1.0
10/03/2001	16.0	6.7	5.5	44.5	0.0001	< 0.0156	59.0	28.4	151	8.6	1.0
05/15/2002	16.5	6.9	5.6	46.1	0.00053	0.0741	60.3	28.5	156	9.4	0.9
10/22/2002	17.7	7.1	5.3	44.4	< 0.0002	< 0.0181	63.1	29.0	149	8.6	0.9
04/15/2003	16.4	6.7	5.2	51.1	< 0.0005	< 0.0101	60.7	26.7	154	9.9	0.8
10/22/2003	16.1	6.6	5.2	49.6	< 0.0016	0.0618	60.5	29.5	141	8.8	0.9
05/04/2004	15.7	6.2	5.4	46.7	< 0.0007	0.0478	58.4	28.1	160	8.2	1.0
10/19/2004	15.7	6.7	5.1	48.6	< 0.0003	< 0.0279	59.7	29.6	169	8.9	0.9
04/19/2005	16.3	6.3	5.2	44.9	< 0.0006	0.0115	58.6	31.3	133	8.4	0.9
10/11/2005	16.0	6.8	5.0	44.0	<0.0002	<0.0270	62.2	29.0	167	8.1	0.9
04/26/2006	16.6	6.7	5.4	51.2	0.0032	0.0612	62.5	28.1	152	8.8	1.1
10/10/2006	16.5	6.5	5.2	48.0	0.0007	0.017	61.2	27.2	156	8.6	1.1

Data source: Data from 1993 through 2000 from BN, 2001.



Table 9 UE5PW-3 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO <sub>2</sub>	SO <sub>4</sub>	HCO <sub>3</sub>	Cl	F
04/14/1993	No analysis	No analysis	No analysis	46	0.042	0.024	No analysis	31	157	8.5	1.3
06/02/1993	No analysis	No analysis	No analysis	53	0.009	0.014	No analysis	31	162	9.1	1.2
10/12/1993	No analysis	No analysis	No analysis	57	<0.006	0.11	No analysis	30	156	7.9	1.2
12/20/1993	No analysis	No analysis	No analysis	48	<0.0012	0.1	No analysis	33	156	8.7	1.3
05/24/1994	No analysis	No analysis	No analysis	56	<0.0012	0.02	No analysis	No analysis	No analysis	No analysis	No analysis
08/08/1994	No analysis	No analysis	No analysis	51	<0.0012	<0.009	No analysis	33	No analysis	8.9	No analysis
04/05/1995	No analysis	No analysis	No analysis	55	<0.01	<0.05	No analysis	31	No analysis	8.8	No analysis
04/30/1996	No analysis	No analysis	No analysis	57	<0.001	0.0088	No analysis	32	No analysis	8.7	No analysis
04/16/1997	15.8	5.7	4.0	54.2	<0.001	<0.006	No analysis	29.0	155	8.4	1.3
11/05/1997	16.8	6.1	4.3	55.5	No analysis	0.0133	No analysis	32.1	140	9.2	1.1
05/13/1998	15.8	5.8	3.3	53.8	<0.0011	0.035	56.8	31.0	151	8.6	1.0
10/28/1998	15.6	5.7	4.2	53.7	0.0009	0.009	57.1	31.4	156	8.7	1.0
05/19/1999	15.0	5.8	4.8	56.0	<0.0025	<0.05	66.3	30.5	146	9.2	0.9
10/27/1999	16.0	6.4	3.8	58.5	<0.005	<0.1	59.9	31.0	159	7.6	0.9
04/26/2000	15.2	5.9	4.5	49.8	0.0003	0.014	58.5	32.0	169	9.1	0.9
08/09/2000	16.0	5.8	4.3	48.2	< 0.0002	< 0.016	57.8	32.6	162	9.9	1.0
05/29/2001	16.7	6.0	4.0	55.1	< 0.0018	< 0.0107	60.5	30.5	150	No analysis	No analysis
10/03/2001	15.6	6.0	4.5	48.5	< 0.0001	< 0.0156	58.0	31.5	151	8.9	<1.0
5/15/2002	15.9	6.1	4.5	49.8	0.00026	0.024	58.6	33.3	151	9.8	0.9
10/22/2002	17.1	6.1	4.2	47.5	< 0.0002	< 0.0181	60.3	32.1	150	9.2	0.8
04/15/2003	16.0	5.9	4.5	54.7	0.00083	0.0195	58.4	29.3	144	11.8	0.8
10/21/2003	16.3	5.8	4.1	54.4	< 0.0016	0.0212	59.5	32.5	160	9.2	1.0
05/04/2004	16.4	5.7	4.6	52.9	< 0.0007	0.0453	58.8	31.0	155	8.7	1.0
10/20/2004	15.6	5.9	4.0	52.3	< 0.0003	< 0.0279	58.4	32.0	166	9.4	0.8
04/19/2005	16.2	5.6	4.5	50.9	< 0.0006	0.0319	57.8	34.4	148	8.8	0.9
10/11/2005	16.1	6.1	4.3	48.5	<0.0002	<0.0260	61.4	32.5	156	8.5	0.9
04/26/2006	16.6	6.1	4.2	58.1	0.0032	0.0057	61.6	31.6	159	9.4	1.2
10/10/2006	15.9	5.5	4.0	49.7	0.0007	0.0114	57.3	30.1	152	9.0	1.0

Data source: Data from 1993 through 2000 from BN, 2001.

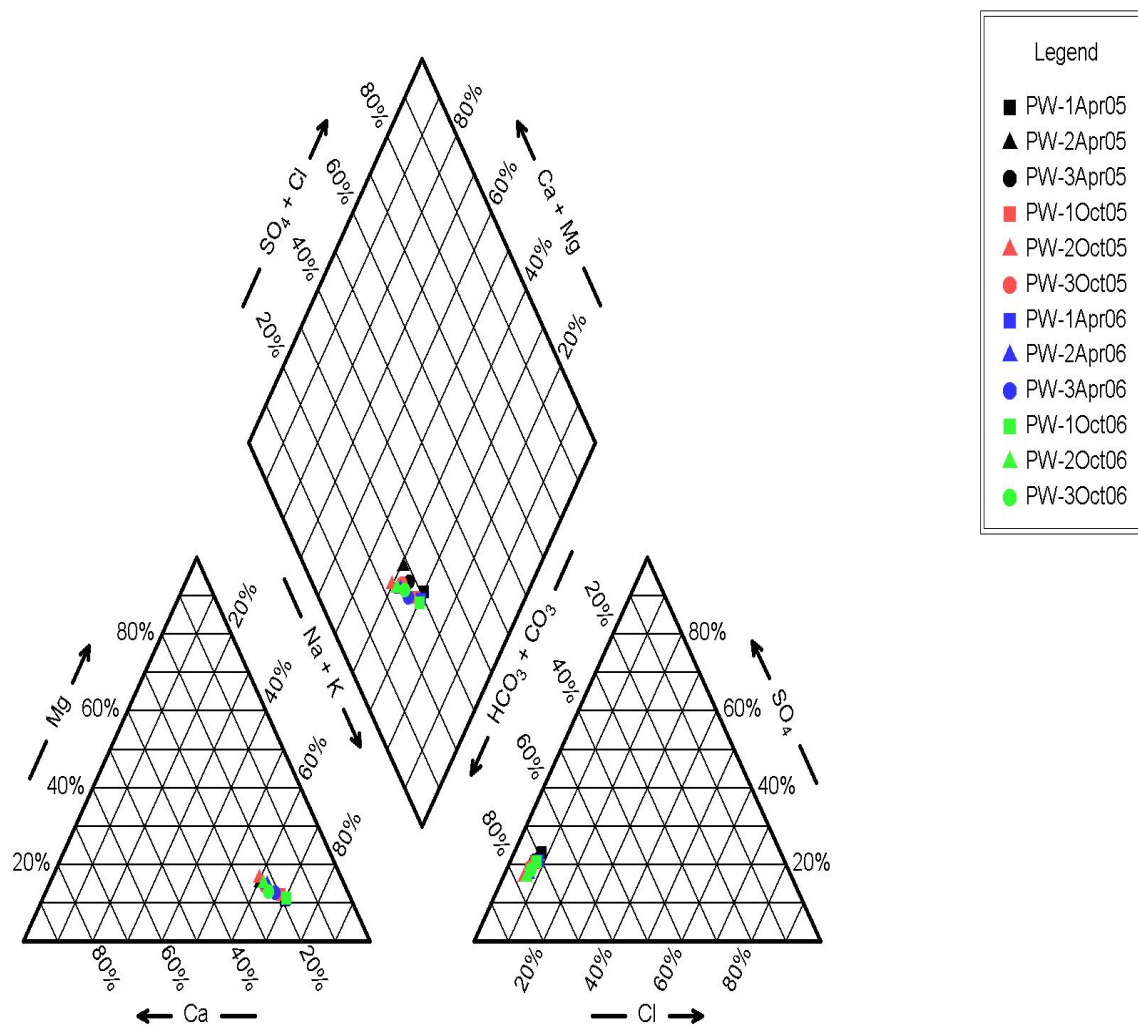


Figure 11. Area 5 RWMS Two-Year Piper Diagram

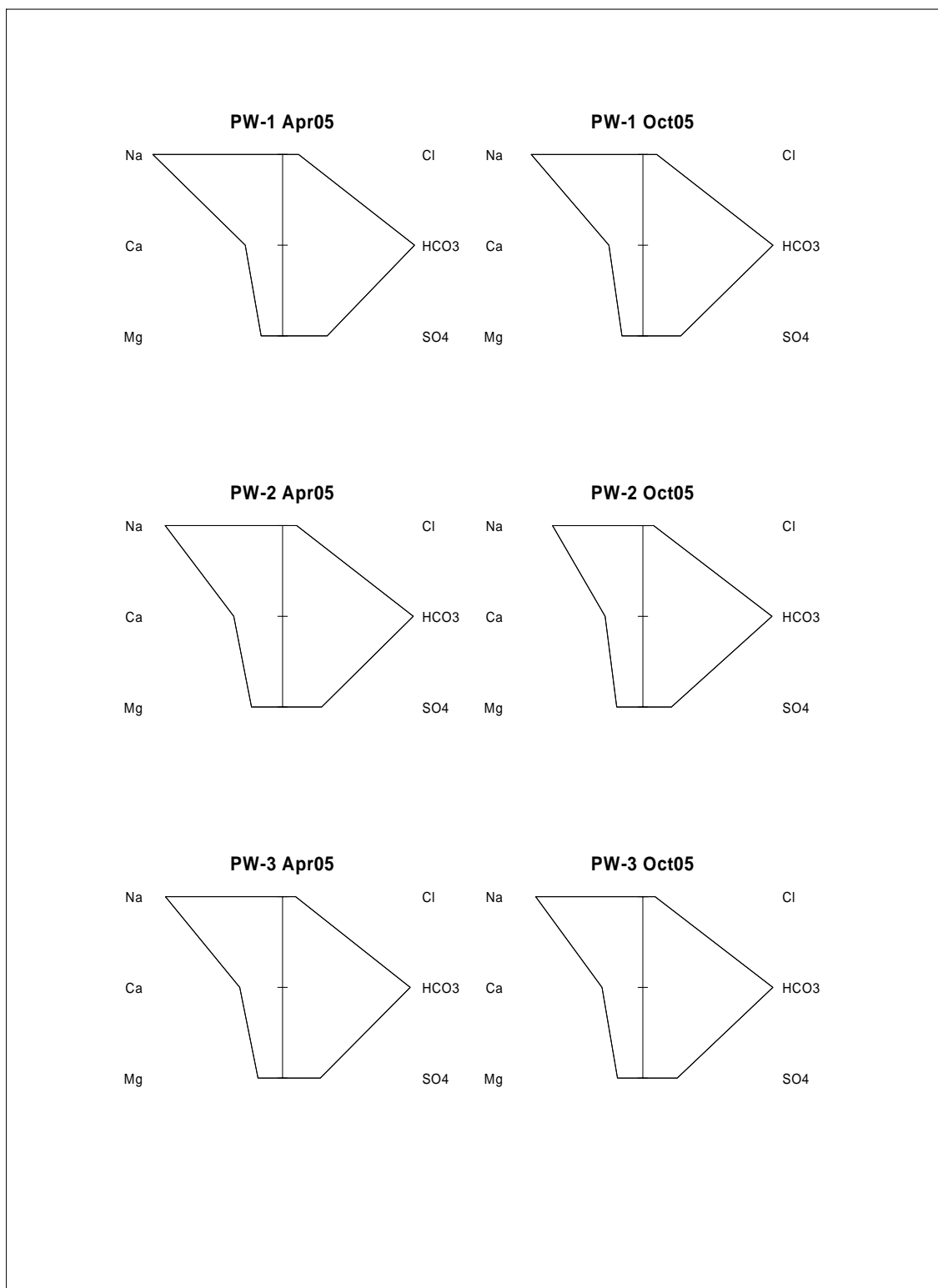


Figure 12. Area 5 RWMS Stiff Diagrams 2005

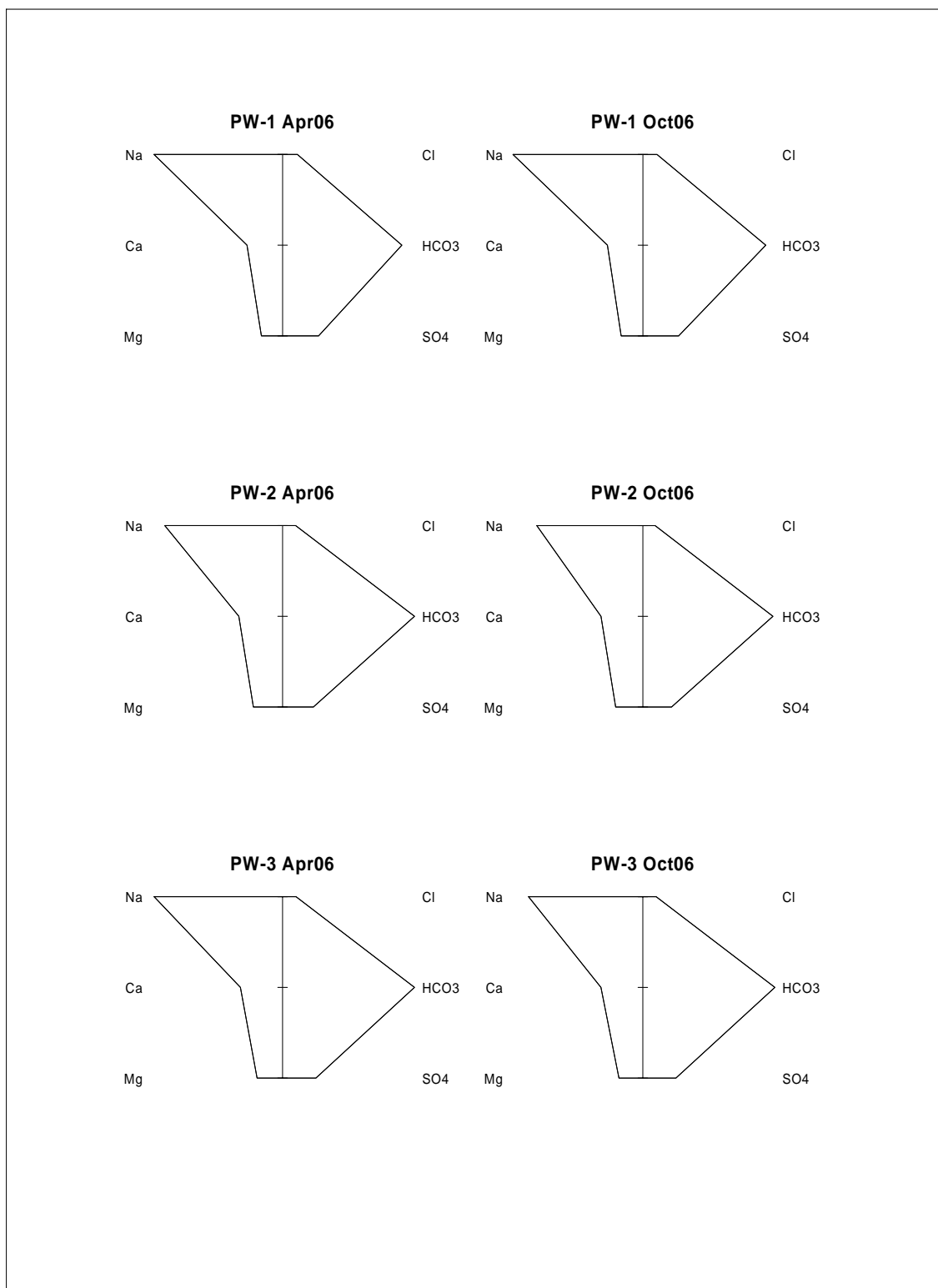


Figure 13. Area 5 RWMS Stiff Diagrams 2006

## **G. Groundwater Elevation**

Groundwater elevations in UE5PW-1, UE5PW-2, and UE5PW-3 are measured quarterly using an electronic water-level tape (Table 10; Figure 14). The 2006 average depths to water from top of casing are: 235.72 m (773.36 ft), 256.40 m (841.20 ft), and 271.52 m (890.79 ft) for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo, 1994).

The 2006 average groundwater elevations are: 733.65 m (2406.99 ft) AMSL, 733.72 m (2407.21 ft) AMSL, and 733.71 m (2407.17 ft) AMSL for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo, 1994). Based on the similar groundwater elevations, the groundwater table is essentially flat with little or no flow. Groundwater gradient, velocity, and flow direction are calculated from the groundwater elevations, borehole locations, and aquifer hydraulic properties (Table 11). The very low calculated flow velocities and the fluctuating flow directions indicate little or no groundwater flow.

## **III. SUMMARY**

The hydrologic conditions in the uppermost aquifer beneath the Area 5 RWMS remain stable. Groundwater flow in this uppermost aquifer is negligible. No significant changes were detected in the water chemistry and all indicator parameters remain within the established ILs.

## **IV. CONCLUSION**

There is no measurable impact to the uppermost aquifer from the Area 5 RWMS.

Table 10. Area 5 RWMS Groundwater Elevation Data

Well Characteristics <sup>a</sup>	UE5PW-1		UE5PW-2		UE5PW-3	
Northing <sup>b</sup> (m)	233,386.48		234,817.13		235,089.93	
Easting <sup>b</sup> (m)	216,357.08		216,376.00		214,415.04	
Well Casing Elevation <sup>c</sup> (m)	969.37		990.12		1,001.92	
Casing stickup height <sup>d</sup> (m)	0.72		0.68		0.76	
Land Surface Elevation (m)	968.65		989.44		1,001.16	
Borehole Deviation Correction (m)	0.08		0.21		0.02	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
03/22/1993	235.55	733.82	256.38	733.74	271.69	733.53
03/23/1993	235.53	733.85	256.48	733.64	271.68	733.54
03/24/1993	235.53	733.84	256.36	733.76	271.69	733.53
03/25/1993	235.53	733.85	256.35	733.77	271.69	733.53
03/29/1993	235.59	733.78	256.38	733.74	271.73	733.49
03/30/1993	235.62	733.75	256.43	733.69	271.75	733.47
03/31/1993	235.62	733.75	256.44	733.67	271.74	733.48
04/01/1993	235.54	733.83	256.37	733.75	271.69	733.53
04/05/1993	235.51	733.86	256.35	733.77	271.67	733.55
04/06/1993	235.59	733.78	256.40	733.71	271.75	733.47
05/10/1993	235.64	733.73	256.46	733.66	271.76	733.46
05/11/1993	235.56	733.81	256.42	733.70	271.70	733.52
05/12/1993	235.54	733.83	256.40	733.72	271.72	733.50
05/13/1993	235.61	733.76	256.45	733.67	271.75	733.47
05/17/1993	235.61	733.76	256.45	733.67	271.74	733.49
05/18/1993	235.59	733.78	256.45	733.67	271.74	733.48
05/19/1993	235.59	733.78	256.44	733.67	271.73	733.49
05/20/1993	235.54	733.83	256.39	733.72	271.70	733.52
05/24/1993	235.60	733.77	256.43	733.69	271.74	733.48
05/25/1993	235.61	733.76	256.45	733.67	271.74	733.48
06/01/1993	235.58	733.79	256.43	733.68	271.73	733.49
06/07/1993	235.64	733.73	256.46	733.66	271.76	733.46
06/14/1993	235.61	733.76	256.46	733.66	271.74	733.49
06/21/1993	235.58	733.79	256.43	733.68	271.73	733.50
07/26/1993	235.59	733.78	256.45	733.67	271.74	733.49
08/03/1993	235.54	733.83	256.42	733.70	271.70	733.52
08/09/1993	235.62	733.75	256.46	733.66	271.75	733.47
08/16/1993	235.59	733.78	256.42	733.70	271.73	733.50
08/30/1993	235.58	733.79	256.43	733.69	271.72	733.50
12/28/1993	235.59	733.78	256.47	733.65	271.74	733.48

Table 10. Area 5 RWMS Groundwater Elevation Data (continued)

Date	UE5PW-1		UE5PW-2		UE5PW-3	
	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
01/03/1994	235.57	733.80	256.44	733.68	271.70	733.53
02/02/1994	235.53	733.84	256.44	733.68	271.66	733.57
02/22/1994	235.60	733.77	256.43	733.69	271.71	733.51
02/28/1994	235.60	733.78	256.45	733.67	271.70	733.53
03/07/1994	235.54	733.83	256.38	733.74	271.66	733.56
03/14/1994	235.55	733.82	256.45	733.67	271.67	733.55
03/21/1994	235.56	733.81	256.38	733.74	271.68	733.54
03/28/1994	235.63	733.74	256.47	733.64	271.70	733.53
04/04/1994	235.53	733.85	256.40	733.72	271.66	733.56
04/13/1994	235.55	733.82	256.43	733.69	271.65	733.57
04/20/1994	235.51	733.86	256.38	733.74	271.64	733.58
04/26/1994	235.55	733.82	256.35	733.77	271.65	733.57
01/18/1995	235.63	733.75	256.45	733.67	271.62	733.60
04/03/1995	235.57	733.80	256.39	733.73	271.61	733.61
01/16/1996	235.36	734.01	256.13	733.99	271.35	733.87
04/15/1996	235.56	733.81	256.30	733.82	271.43	733.79
10/01/1996	235.54	733.83	256.32	733.80	271.51	733.71
11/19/1996	235.59	733.78	256.33	733.79	271.52	733.70
03/03/1997	235.54	733.83	256.30	733.82	271.41	733.81
04/15/1997	235.63	733.74	256.40	733.72	271.54	733.68
06/18/1997	235.61	733.76	256.40	733.72	271.52	733.71
07/28/1997	235.60	733.77	256.37	733.75	271.51	733.71
08/20/1997	235.52	733.85	256.29	733.83	271.44	733.78
09/25/1997	235.59	733.78	256.35	733.77	271.49	733.73
10/27/1997	235.57	733.80	256.34	733.78	271.48	733.74
11/03/1997	235.65	733.72	256.40	733.72	271.55	733.67
11/06/1997	235.57	733.80	256.36	733.75	271.48	733.74
11/12/1997	235.66	733.71	256.45	733.67	271.54	733.68
11/13/1997	235.60	733.77	256.29	733.83	271.49	733.73
11/19/1997	235.63	733.74	256.42	733.70	271.55	733.67
11/20/1997	235.65	733.72	256.43	733.69	271.57	733.65
11/25/1997	235.64	733.73	256.39	733.73	271.54	733.68
11/26/1997	235.50	733.87	256.27	733.85	271.45	733.77
12/03/1997	235.71	733.66	256.43	733.68	271.60	733.62
01/26/1998	235.72	733.65	256.47	733.65	271.60	733.62
05/12/1998	235.60	733.77	256.32	733.80	271.52	733.70
10/27/1998	235.52	733.85	256.21	733.91	271.36	733.86
12/22/1998	235.54	733.83	256.20	733.92	271.35	733.87
02/02/1999	235.61	733.76	256.34	733.78	271.42	733.80
05/18/1999	235.56	733.81	256.26	733.85	271.35	733.87
08/25/1999	235.56	733.81	256.26	733.85	271.38	733.84
10/26/1999	235.57	733.80	256.26	733.86	271.34	733.88
04/24/2000	235.64	733.73	256.34	733.78	271.52	733.71
08/07/2000	235.59	733.78	256.30	733.82	271.47	733.75
11/13/2000	235.66	733.71	256.34	733.78	271.45	733.77
02/22/2001	235.57	733.80	256.26	733.86	271.38	733.85
05/21/2001	235.67	733.70	256.35	733.77	271.49	733.73
08/01/2001	235.66	733.71	256.36	733.76	271.48	733.74

**Table 10. Area 5 RWMS Groundwater Elevation Data (continued)**

Date	UE5PW-1		UE5PW-2		UE5PW-3	
	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
10/01/2001	235.66	733.71	256.35	733.77	271.45	733.77
02/26/2002	235.76	733.61	256.43	733.69	271.52	733.70
05/13/2002	235.65	733.72	256.39	733.73	271.44	733.78
08/19/2002	235.61	733.76	256.28	733.84	271.42	733.81
10/21/2002	235.61	733.76	256.31	733.81	271.44	733.78
02/26/2003	235.65	733.72	256.28	733.84	271.43	733.79
04/10/2003	235.61	733.76	256.30	733.82	271.41	733.82
09/10/2003	235.74	733.63	256.35	733.77	271.50	733.72
10/20/2003	235.73	733.64	256.42	733.70	271.53	733.69
02/25/2004	235.78	733.59	256.36	733.76	271.52	733.70
04/27/2004	235.72	733.65	256.43	733.68	271.52	733.70
08/18/2004	235.72	733.65	256.38	733.74	271.48	733.74
10/18/2004	235.71	733.66	256.29	733.82	271.47	733.75
01/26/2005	235.67	733.70	256.45	733.67	271.46	733.76
04/18/2005	235.66	733.71	256.33	733.79	271.44	733.78
07/27/2005	235.75	733.62	256.42	733.70	271.51	733.71
10/10/2005	235.77	733.60	256.44	733.67	271.54	733.68
03/08/2006	235.74	733.63	256.39	733.73	271.50	733.72
05/03/2006	235.69	733.68	256.41	733.71	271.62	733.60
08/23/2006	235.76	733.61	256.43	733.69	271.50	733.72
10/09/2006	235.69	733.68	256.38	733.74	271.44	733.78

<sup>a</sup> Source for northings, eastings, well casing elevations, and borehole deviation corrections: REECO, 1994<sup>b</sup> Coordinate System: Nevada (Central) State Plane NAD27<sup>c</sup> Measured from top of well casing<sup>d</sup> Measured from top of well casing to land surface

Note: All elevations are m above mean sea level



Table 11. 2005 Area 5 RWMS Groundwater Flow Calculations

Hydraulic Conductivity = 1.12E-03 cm/second (3.67E-05 ft/second) <sup>a</sup> Effective Porosity = 0.38 <sup>a</sup>			
Date	Hydraulic Gradient (m/m)	Velocity (m/yr)	Flow direction (degrees East of North)
03/08/2006	7.16E-05	0.07	11.6
04/24/2006	6.13E-05	0.06	72.5
08/23/2006	5.79E-05	0.05	174.1
10/09/2006	4.51E-05	0.04	161.6

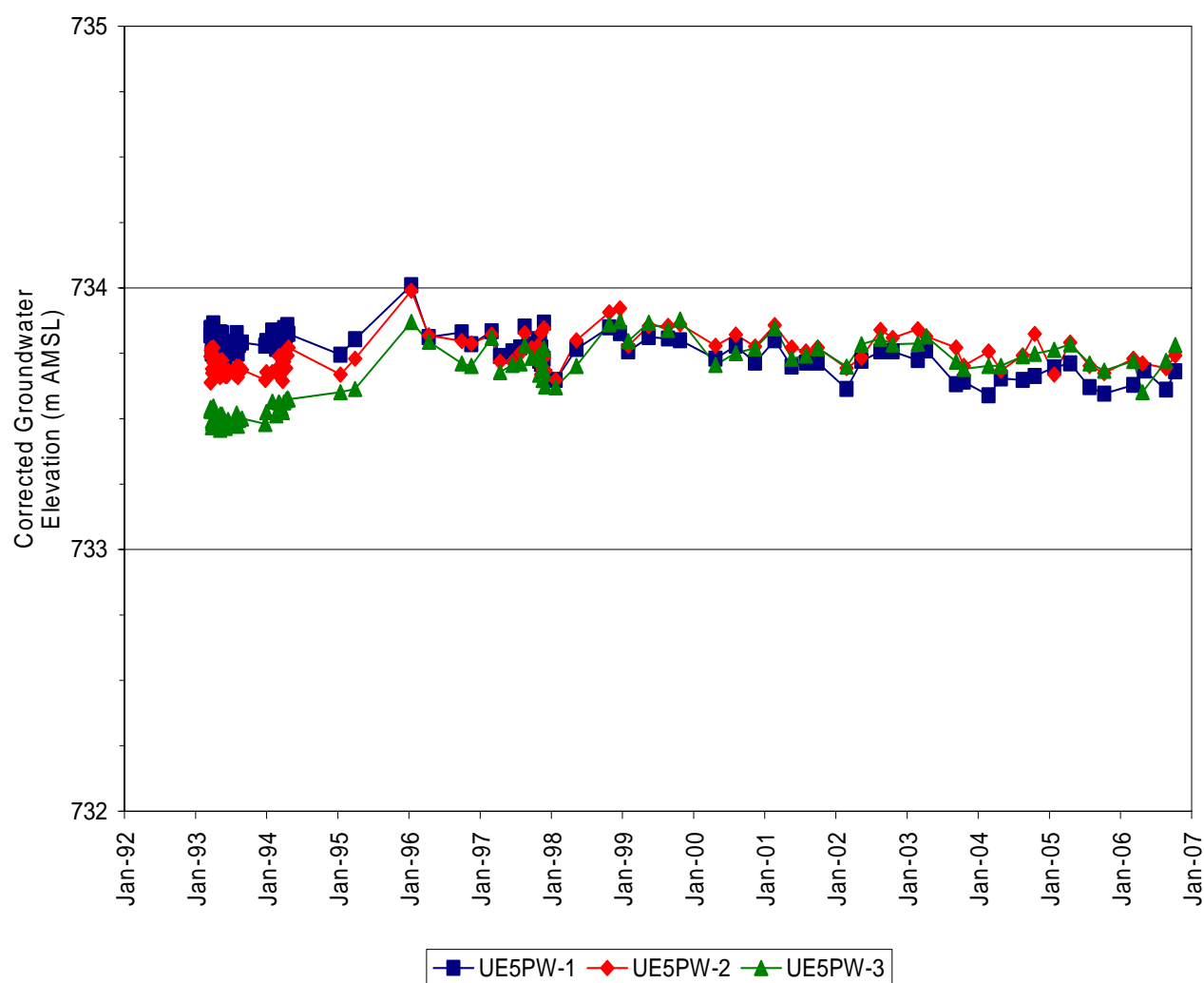
<sup>a</sup> Source: REECO, 1994

Figure 14. Area 5 RWMS Time Series Plot of Groundwater Elevation

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## **Appendix A – Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program**

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Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program								
Date	UE5PW-1		Date	UE5PW-2		Date	UE5PW-3	
03/20/1990	DOE letter requesting installation of monitoring wells near the Area 5 RWMS.							
03/13/1992	Drilling begins							
06/16/1992	Drilling ends		06/18/1992	Drilling begins				
09/11/1992	Well Developed		09/04/1992	Drilling ends				
					09/16/1992	Drilling begins		
					11/09/1992	Drilling ends		
			03/24/1993	GW Sampling				
03/31/1993	GW Sampling		03/30/1993	Well Developed		04/04/1993	Well Developed	
						04/14/1993	GW Sampling	
06/06/1993	GW Sampling		06/22/1993	GW Sampling		06/02/1993	GW Sampling	
09/01/1993	GW Sampling					10/12/1993	GW Sampling	
12/07/1993	GW Sampling		11/15/1993	GW Sampling		12/20/1993	GW Sampling	
12/17/1993	DOE letter to NDEP requesting to establish Pilot Wells located near the Area 5 as RCRA groundwater monitoring wells.							
02/24/1994	NDEP letter stating that the Pilot Wells appear to meet the applicable design, construction, and development criteria for RCRA groundwater monitoring wells.							
06/15/1994	GW Sampling		06/07/1994	GW Sampling		05/24/1994	GW Sampling	
08/01/1994	GW Sampling					08/08/1994	GW Sampling	
			11/29/1994	GW Sampling				
09/30/1994	DOE submits 1993 groundwater-monitoring results from quarterly sampling effort.							
01/18/1995	UE5PW-3 GW resampling for 08/01/1994 TOC hit.							
02/23/1995	DOE transmits to NDEP Groundwater Monitoring Program Outline.							
03/01/1995	1994 Groundwater Monitoring Report submitted to NDEP.							
04/04/1995	GW Sampling							
11/09/1995	GW Sampling							
11/09/1995	UE5PW-1 pump snagged in hole, resulting in a bent shaft on the reel.							
01/18/1996	GW Sampling		1/25/96		GW Sampling		1/18/96	GW Sampling
01/22/1996	Bennett pump seals replaced at all three wells.							

Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	UE5PW-1	Date	UE5PW-2	Date	UE5PW-3
03/01/1996	DOE submits to NDEP the 1995 GW Monitoring Report.				
04/16/1996	GW Sampling	04/23/96	GW Sampling		
		04/30/1996	GW Sampling		
10/02/1996	GW Sampling				
10/25/1996	NDEP requests clarifications/changes in the GW Monitoring Report.				
11/20/1996	GW Sampling				
03/01/1997	DOE submits 1996 GW Monitoring Report and revised GW Monitoring Program Outline.				
04/16/1997	GW Sampling				
08/12/1997	NDEP comments on 1996 GW Monitoring Report/Proposed Outline.				
10/22/1997	Pump and water-level meter lodge in UE5PW-1 well during simultaneous operation, retrieved 10/23/1997.				
10/22/1997	Larger diameter air lines installed at all three wells.				
11/05/1997	GW Sampling				
03/01/1998	DOE submits to NDEP the 1997 GW Monitoring Report and new outline.				
03/31/1998	NDEP letter stating that they concur on the indicator parameters and ILs submitted in the groundwater-monitoring outline.				
05/13/1998	GW Sampling				
06/22/1998	TOX detected in the 05/13/1998 samples and blanks from all three wells.				
07/10/1998	DOE and NDEP agree to resample UE5PW-1 to confirm no TOX.				
07/29/1998	GW resampling at UE5PW-1 for 05/13/1998 TOX hits.				
09/10/1998	Results from 07/29/1998 resampling are non-detect for TOX. TOX results from the 05/13/1998 sampling event are determined to be false positives.				
09/10/1998	Bennett pumps from three wells and spare pumps are sent to manufacturer for refurbishing.				
09/12/1998	Reels from three wells are returned to manufacturer for new tubing bundles.				
10/28/1998	GW Sampling				
09/12/1998	UE5PW-1 reel returned to manufacturer for repair of exhaust tube. Spare pump returned to manufacturer for the repair of a leaky seal.				
03/01/1999	DOE submits to NDEP 1998 Groundwater Monitoring Report.				
03/31/1999	NDEP requests statistical analysis of data and states that values determined to be false positives through resampling do not need to be presented graphically.				
05/19/1999	GW Sampling				
10/27/1999	GW Sampling				
12/13/1999	Resample UE5PW-2 after TOC hit from 10/27/1999.				
12/27/1999	Results from the resampling of UE5PW-2 are non-detect for TOC. TOC result from 10/27/1999 is determined to be a false positive.				



Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	UE5PW-1	Date	UE5PW-2	Date	UE5PW-3
02/25/2000	DOE submits to NDEP 1999 Groundwater Monitoring Report				
04/17/2000	NDEP states that future reports do not need to include statistical analyses.				
04/26/2000	GW Sampling				
06/28/2000	DOE contacts state to report TOX/TOC hits from 04/26/2000. DOE and NDEP agree that the wells will be resampled in August, which would also constitute the Fall sampling event.				
08/09/2000	GW Sampling				
09/20/2000	DOE contacts NDEP to report TOX hits from 08/09/2000 sampling.				
11/07/2000	Letter from NDEP stating that DOE does not have a valid data set for TOX and possibly TOC and requests a plan to address contamination concerns prior to next sampling event.				
11/20/2000	Video log well			11/27/2000	Video log well
12/20/2000	DOE transmits to NDEP a proposed plan to address contamination issues.				
01/31/2001	Letter from NDEP generally concurring that the plan submitted to determine the cause of TOX and TOC hits is sound.				
02/21/2001	DOE submits to NDEP 2000 Groundwater Monitoring Report				
03/14/2001	Letter from NDEP stating that the 2000 Groundwater Monitoring report was received in a timely manner and contains all the data required by Title 40 CFR 265.94. Letter also requests information regarding data in Appendix A of the 2000 Groundwater Monitoring Report (Bechtel Nevada [BN], 2001).				
04/19/2001	Letter from DOE responding to NDEP's 3/14/2001 request for information regarding presentation of TOX/TOC data in the 2000 report.				
04/30/2001	Letter from NDEP concurring with the approach to data presentation as outlined by DOE in the 4/19/2001 correspondence.				
05/29/2001	GW Sampling				
10/03/2001	GW Sampling				
03/01/2002	DOE submits to NDEP 2001 Groundwater Monitoring Report				
05/15/2002	GW Sampling				
10/22/2002	GW Sampling				
03/01/2003	DOE submits to NDEP 2002 Groundwater Monitoring Report				
04/15/2003	GW Sampling				
10/22/2003	GW Sampling			10/21/2003	GW Sampling
03/01/2004	DOE submits to NDEP 2003 Groundwater Monitoring Report				
05/04/2004	GW Sampling				

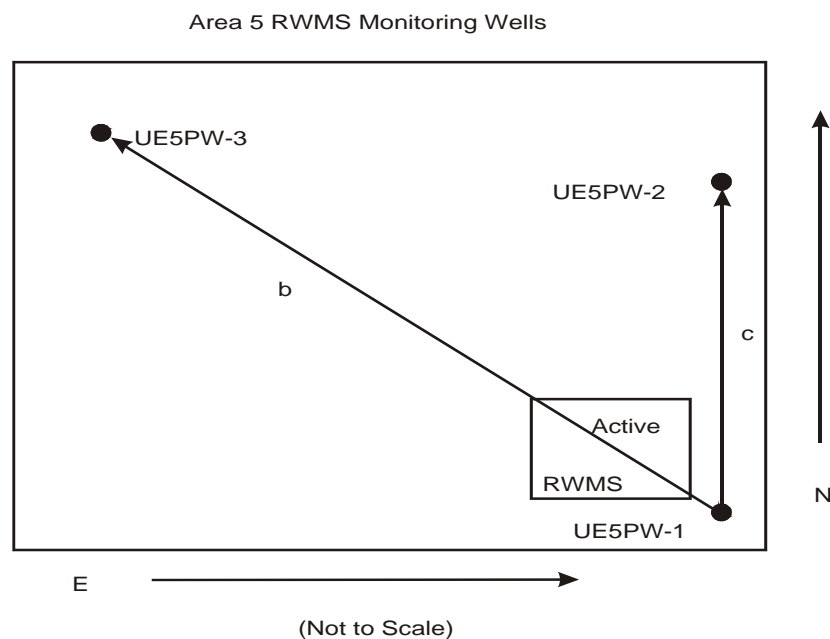
Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	UE5PW-1	Date	UE5PW-2	Date	UE5PW-3
10/19/2004	GW Sampling			10/20/2003	GW Sampling
02/25/2005	DOE submits to NDEP 2004 Groundwater Monitoring Report				
04/19/2005	GW Sampling				
10/11/2005	GW Sampling				
03/01/2006	DOE submits to NDEP 2005 Groundwater Monitoring Report				
04/26/2006	GW Sampling				
10/10/2006	GW Sampling				

## **Appendix B – Gradient/Velocity Calculations**

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## CALCULATION OF MAGNITUDE AND DIRECTION OF AREA 5 ALLUVIAL AQUIFER GRADIENT

Water level elevations measured at three wells in the alluvial aquifer near the Area 5 RWMS are used to calculate the magnitude and direction of the hydraulic gradient. The wells sampled are UE5PW-1, UE5PW-2, and UE5PW-3. The locations of the three wells are given in Nevada State Central Zone coordinates in meters as Northing (N) and Easting (E) values (see figure below).



The coordinates of each of the three points on the plane are given by (E, N, e)

Where:

E is the East coordinate,

N is the North coordinate, and

e is the water table elevation.

The vector **b** representing the line segment 13 is given by  $(E_3 - E_1)\mathbf{i} + (N_3 - N_1)\mathbf{j} + (e_3 - e_1)\mathbf{k}$ . Similarly the vector **c** representing the line segment 12 is given by  $(E_2 - E_1)\mathbf{i} + (N_2 - N_1)\mathbf{j} + (e_2 - e_1)\mathbf{k}$ . A normal vector to the plane is given by the vector product of **b** and **c**.

$$\mathbf{b} \times \mathbf{c} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ [E_2-E_1] & [N_2-N_1] & [e_2-e_1] \\ [E_3-E_1] & [N_3-N_1] & [e_3-e_1] \end{vmatrix}$$

Expanding the determinant gives,

$$\begin{aligned} & [ [N_2-N_1] [e_3 - e_1] - [N_3-N_1] [e_2 - e_1] ] \mathbf{i} - \\ & [ [E_2-E_1] [e_3 - e_1] - [E_3-E_1] [e_2 - e_1] ] \mathbf{j} + \\ & [ [E_2-E_1] [N_3 -N_1] - [E_3-E_1] [N_2-N_1] ] \mathbf{k}. \end{aligned}$$

This gives the representation for the plane as,

$$A (E) + B (N) + C (e) = D$$

Where:

$$A = [N_2-N_1] [e_3-e_1] - [N_3-N_1] [e_2-e_1]$$

$$B = -[[E_2-E_1] [e_3-e_1] - [E_3-E_1] [e_2-e_1]]$$

$$C = [E_2-E_1] [N_3-N_1] - [E_3-E_1] [N_2-N_1].$$

The constant D can be determined by substituting the N, E, and e values for PW-1 into the equation for the plane.

The equation is then written in terms of the elevation:

$$e = -A/C (E) - B/C (N) + D/C.$$

The gradient is given by the derivative of the function e in the direction of the unit vector  $\mathbf{u}$ .

$$D_{\mathbf{u}}e = \nabla e \cdot \mathbf{u}$$

$\nabla e$  points in the direction  $\mathbf{u}$  that produces the largest directional derivative.  $|\nabla e|$  is that largest directional derivative. For the water table elevations,

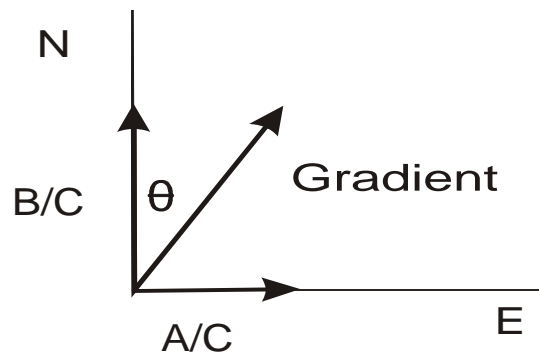
$$\nabla e = -A/C \mathbf{i} + B/C \mathbf{j}.$$

The gradient is calculated from the E and N components,

$$\text{Gradient} = \sqrt{(A/C)^2 + (B/C)^2}$$

The direction of the gradient with respect to North is calculated from the component vectors.

The direction of the gradient is given by:



$$\theta = 90 - \text{Arctan}(B/A).$$

### Calculation of Mean Groundwater Velocity

Once the gradient has been calculated, the mean groundwater velocity may be calculated using Darcy's Law:

$$q = Ki$$

where

$$V = q/\Phi$$

Where:

q equals the specific discharge or Darcian flux

K is the saturated hydraulic conductivity (length/time)

i is the hydraulic gradient (dimensionless)

$\Phi$  is the effective porosity (dimensionless)

V is the mean groundwater velocity (length/time)

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